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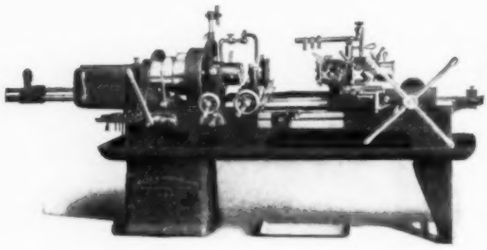

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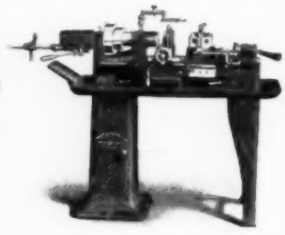

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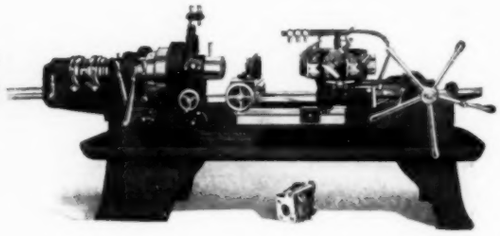

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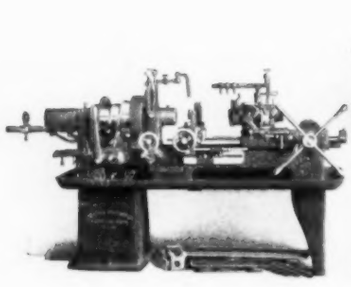

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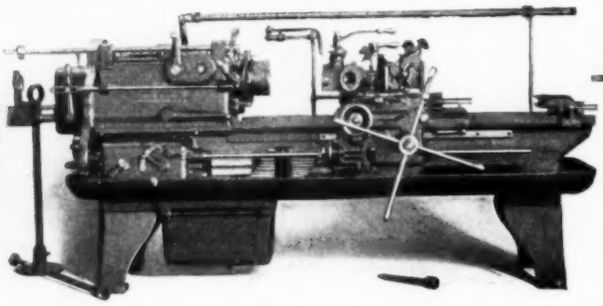

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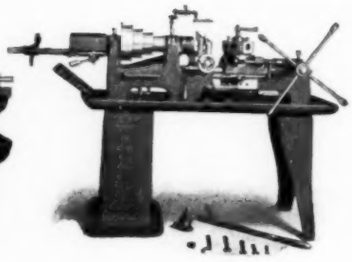

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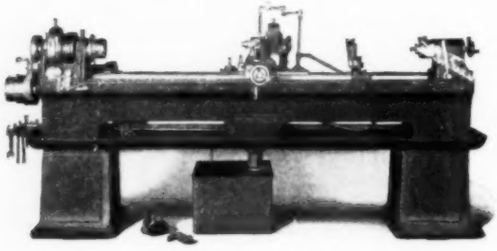

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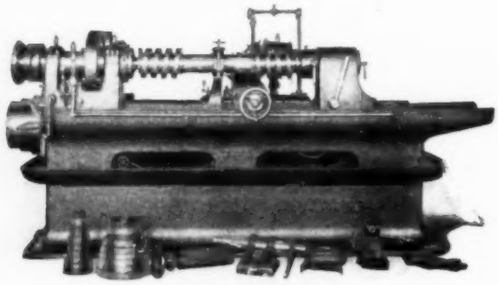

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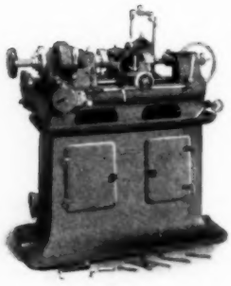

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Balancing a Rock Crusher—A Peculiar Problem

A Graphical Solution Determined the Unbalanced Forces. Addition of Weights to Flywheels Reduced Vibration from 0.48 to 0.03 Inch

BY O. P. HOOD*

At the Lake Superior copper mines it is the practice to hoist the broken rock well above the surface, so that after being fed through crushers the rock can still be stored and fed by gravity into cars on standard railroad track. This necessitates putting heavy crushers 50 to 60 feet above the ground. In the new rock houses crushers of so large a capacity and weight have been installed, that it is common to have two or three crushers of the Blake type, each with a throat opening 36x24 inches and running at speeds from 125 to 175 revolutions per minute. The heavy jaws of these crushers vibrate from ½ to ¾ inch, and since this vibrating mass is not balanced in any way the building to which the crusher frame is fastened must furnish the reaction to the vibrating mass. The buildings are of steel, heavy, and well braced, but do not cover a large ground area, and are thus less able to withstand cross-stresses than direct vertical loads. Even with elaborate bracing it is with difficulty that some of the buildings have been kept from considerable vibration and crusher speeds have been lowered to protect the building.

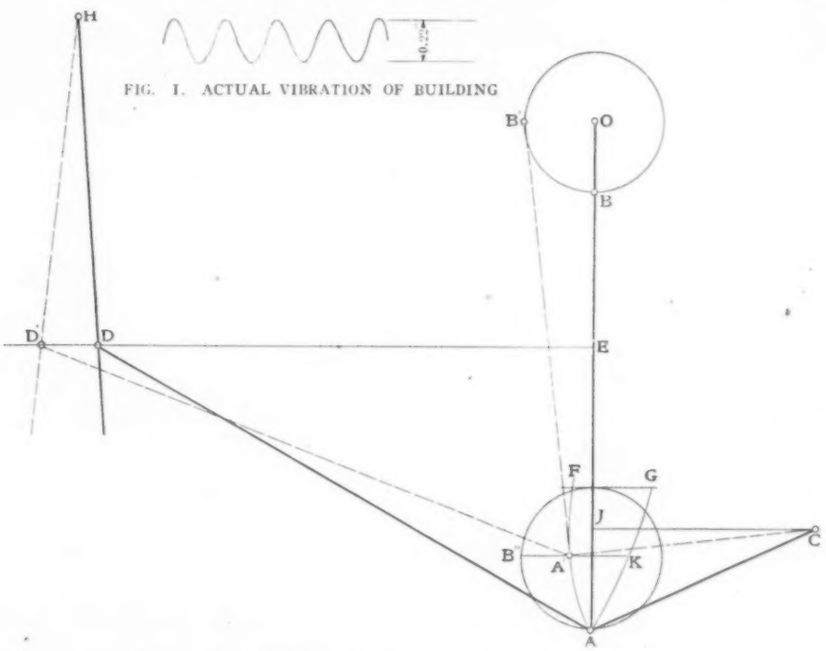


FIG. 2. DIAGRAMMATIC ARRANGEMENT OF CRUSHER PARTS

To illustrate how much this vibration can be, Fig. 1 is given. This is reproduced from an autographic diagram giving the actual vibration in inches. There were running in the building three 36x24 Farrell crushers on a floor 52 feet above the surface. The vibration at this level was 0.22 inch when the crushers were running 175 revolutions per minute. When the crushers were thrown off and the engine run alone the diagram was practically a straight line, showing that the vibration was due to the crushers. Rather than add to the building by heavy bracing it seems more desirable to balance the forces which produced the vibration, and the method of going at this problem is here presented.

FIG. 1. ACTUAL VIBRATION OF BUILDING

The Problem

The problem might be stated as follows: A mass of approximately eight tons vibrates 175 times a minute through a short path, the nature of the vibration being determined by an eccentric revolving at a uniform speed, a pitman, toggle joint and swinging jaw. Is the nature of this movement such that a rotating weight, properly placed, can balance the inertia of the swinging jaw and parts moving with it? The forces which move the jaw must react against the frame and building to which it is attached and move the mass of these to produce the vibration. To find the amount of force it is necessary to find the velocity of the moving jaw, from which we can find the acceleration of the mass. It is quite probable that someone will readily solve this problem by analytical methods. In fact by making certain assumptions, such as that the two links in the toggle are of the same length, symmetrically disposed, and fall in one straight line when at their upper limit, the problem is not difficult. But the actual crusher is just enough different than this to make such assumptions lead to incorrect results, and a mathematical expression for the jaw movement I found difficult to obtain. The graphical method appeared much easier.

Diagrammatic Arrangement of Crusher Parts

Fig. 2 shows diagrammatically the arrangements of parts of a crusher although very much distorted. Let $B\,B'$ represent the path of the eccentric crank, $A\,B$ the pitman articulated at A to the two links $A\,C$ and $A\,D$. Link $A\,C$ abuts against the frame at C and the point D is constrained to move about H as a center, or practically in the direction $E\,D$. As the eccentric revolves, the point D (a part of the jaw $D\,H$) has a small motion which crushes the rock against the frame. The character of this motion is readily found by finding the position of D for several positions of B, as shown in dotted lines at $B'\,A'\,D'$. An inspection of this diagram shows that A moves about C as a center and also relatively about D, so that if the eccentric circle be drawn $A\,B''\,F\,G$ and arcs $A\,F$ from C and $A\,G$ from D as a center, the distance, as $A'\,K$ between the two arcs opposite any point in the circle as B'' measures the distance the point D has moved from its inner position. Thus $A'\,K$ is equal to $D'\,D$, and this corresponds to the position of the crank shown at B'.

In the actual crusher under consideration the eccentricity $O\,B$ is ½ inch, $A\,B$ 37 inches, $A\,C$ 13 inches, $A\,D$ 23 inches, $J\,A$ 3½ inches, $J\,E$ 3 inches.

The jaw movement and the eccentric circle are so small that it is well to magnify the movement image, as in Fig. 3, where the arcs $A\,F$ and $A\,G$ are drawn properly in proportion to the eccentric circle, which is here marked into ten-degree spaces. Since the eccentric revolves uniformly these ten-degree spaces are passed in equal times and, when plotted in Fig. 4, as horizontal distances, represent time. Laying off vertically in Fig. 4 the several distances similar to $A'\,K$ for each angle of the eccentric, we find the curve $O\,J$, whose distance from the axis $O\,X$ represents the jaw movement magnified. The actual maximum jaw movement was

*Professor of mechanical and electrical engineering, Michigan College of Mines.

found to be 0.484 inch and this is represented in the diagram by $X J$, which measures 1.95 inches, therefore, one inch in hight of the diagram represents 0.248 inch of jaw movement. From the curve $O J$ we can find the velocity at any point, for the velocity is the rate at which the jaw is changing its position, and by drawing tangents as $L M$ at the 40-degree point, then the vertical distance $M N$ represents the distance the jaw would have traveled while the eccentric was moving the time $L N$ provided the rate had been uniform. The distance $L N$ is taken as any convenient distance as 150 degrees, but is taken the same for each point on the curve $O J$. Plotting the $M N$ distances with time as the base gives the curve $O V X$, which is the velocity curve of the jaw. The scale of this curve can be found from any of the triangles $L M N$, for the time is given by the constant base $L N$ and the space by $M N$, the velocity being equal to the space divided by the time. The distance $M N$ measures 1.74 inches, which equals $1.74 \times 0.248 = 0.431$ inch, movement of the jaw. It is convenient to assume one revolution per second for the speed so that since the base $L N = 150$ degrees the time will be $150 \div 360 = 0.417$ second.

The velocity when running at 60 revolutions per minute equals $0.431 \div 0.417 = 1.034$ inches per second at the 40-degree point, and this is represented by the hight $M N$ of 1.74 inches. One inch in hight of the velocity curve, therefore, represents $1.034 \div 1.74 \times 12 = 0.05$ foot per second.

Graphical Solution of the Problem

To change the velocity of a mass requires a force proportional to the amount of change of velocity made in a second, that is, in proportion to the acceleration which is the rate of change of velocity. From the velocity curve we can find this acceleration by drawing tangents as before. To illustrate, at the 60-degree point the velocity is changing at the rate shown by the tangent $L' M'$ and in the time $L' N'$ would change the amount $M' N'$. Plotting these values of $M' N'$ for each of the points of the velocity curve we have the acceleration curve $R K' S$. When the velocity is the greatest, and

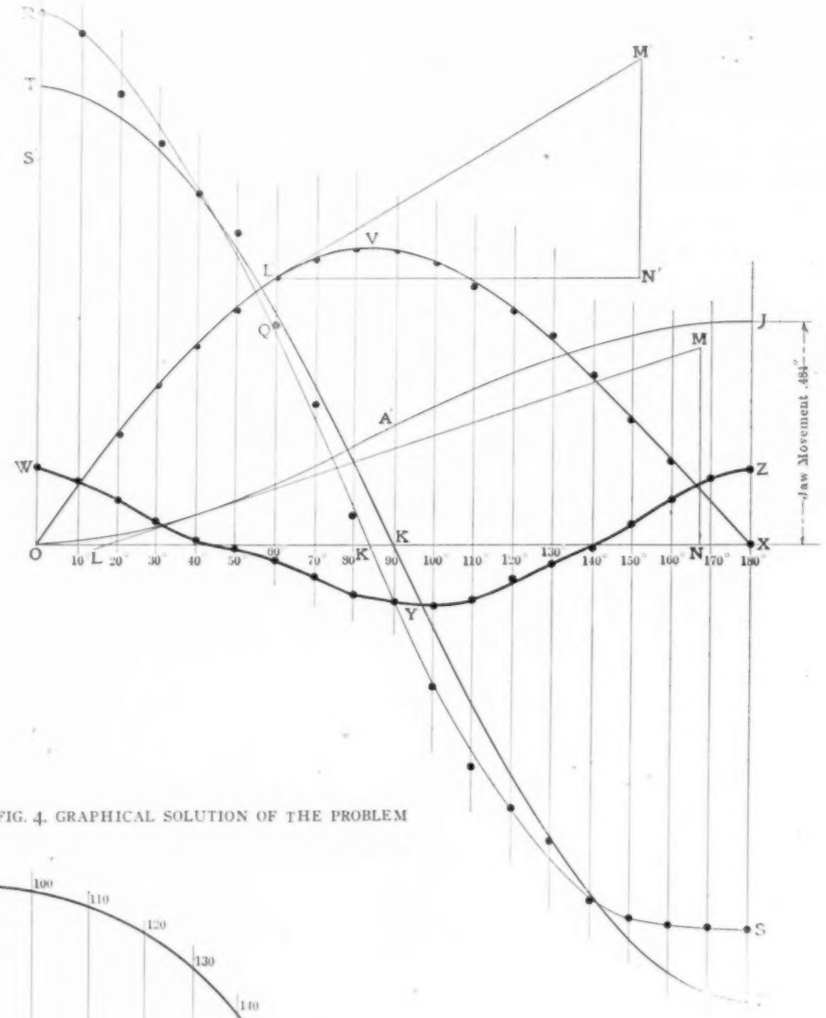


FIG. 4. GRAPHICAL SOLUTION OF THE PROBLEM

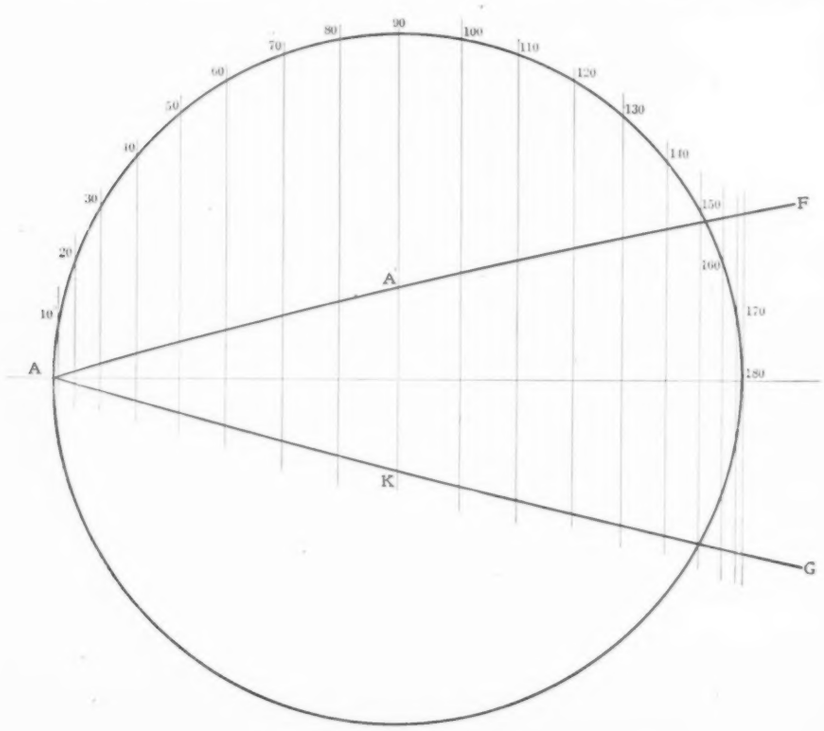


FIG. 3. DIAGRAM MAGNIFYING THE JAW MOVEMENT

before it begins to decrease, the velocity is unchanging for an instant, therefore there is no acceleration as shown by the curve $R K' S$ having a zero value at K'. Up to this point the jaw has been increasing in velocity and, therefore, requiring a force to make the change, but after passing K' the jaw velocity is decreasing and it now requires a force to stop it. This must evidently be in the opposite direction to the first force and is, therefore, shown below the line $O X$. Since the forces required are proportional to the acceleration, the curve $R K' S$ must also represent to some other scale the forces tending to shake the machine in the line of direction of the movement of the jaw. That particular point on the jaw, whose movement has the same effect as if all the moving mass was concentrated at that point, is called the radius of gyration measured from the point H about which the jaw swings. By compu-

tation from the drawings of the section of the casting this was found to be 44 inches from the center, and here the velocities would be greater than at D in the proportion of 44 to 37, or 19 per cent. more.

The scale of the curve $R\,K'\,S$ can be found from the triangle $L'\,M'\,N'$, where $M'\,N' = 1.92$ inches. This represents $1.92 \times 0.05 = 0.096$ foot per second, as the velocity gained in the time $L'\,N'$. One-half second is represented by $O\,X$, which is 6.28 inches long. Therefore, $L'\,N'$ represents 0.254 second. The acceleration is $0.096 \div 0.254 = 0.384$ foot per second per second. This is represented by a line $M'\,N'$ 1.92 inches long, therefore, each inch in hight represents $0.384 \div 1.92 = 0.2$ foot per second per second acceleration.

The maximum force required is evidently at the beginning of the jaw movement when the force is represented by OR. Here at 60 revolutions per minute the acceleration is 4.7 inches $\times$ 0.2 = 0.94 foot per second per second, which at the radius of gyration of the jaw will be 19 per cent. more, or 1.12 feet per second per second. The mass moved weighs 16,000 pounds. The force required to move this will be $16{,}000 \div 32$, equals 500, multiplied by the acceleration 1.12 or 560 pounds when running at 60 revolutions per minute. The force of acceleration will vary as the square of the velocity, so that it is no wonder that several such crushers will shake a building when run at 175 revolutions per minute as many do, when the shaking force for each crusher amounts to nearly two and a half tons.

From the curve of acceleration it is noted that this force is applied as a push to the building at the beginning of the jaw movement, growing less in amount until it reverses just before the quarter revolution. The force then becomes a pull on the building, reaching an amount about 72 per cent. of the maximum push, but keeping at it longer. From 180 to 360 degrees the acceleration curve would be symmetrical about the line $J\,S$ so that there would be a push on the building for about 46 per cent. of the time, and a pull for 54 per cent. An inspection of the curve shows that it does not depart widely from that form which would be made by an unbalanced weight revolving with the eccentric. Such a curve would be a sine curve.

Laying off $O\,S'$ equal to $X\,S$ we will take a point T half way between S' and R and assume this as the average force to be balanced, for if under-balanced at R it will be equally over-balanced at S. The curve $T\,T'$ is readily laid in as a sine curve. To furnish this balancing force we can place a weight in the flywheel that can give the forces $T\,T'$, but this must be in such phase with the moving jaw that $O\,T$ shall oppose $O\,R$ instead of being in phase with it as shown.

Determining the Location and Magnitude of the Counterweights

We find that there is a convenient place in the flywheel of the crusher where the counterweights mass will be about 2 feet from the center of the shaft. Here the velocity at one revolution per second will be 12.50 feet per second, and the force will be equal to the weight times the velocity squared divided by 32 times the radius in feet. The force $O\,T$ scales 480 pounds, if $O\,R$ represents 560, so that the weight we seek figures 196 pounds. Half of this can be put in each flywheel in such place that, as the jaw begins to move forward the counterweight will begin to move back.

This analysis furnishes an explanation

A Horizontal Distances Actual Amount of Movement of Breaker and Car (about 45 Tons) when Running 50 Revolutions per Minute, and as Originally Made. Vertical Distances represent Enlarged Travel of Pitman.

B Same with Fly-wheels well Balanced.

C Same with all Parts Balanced.

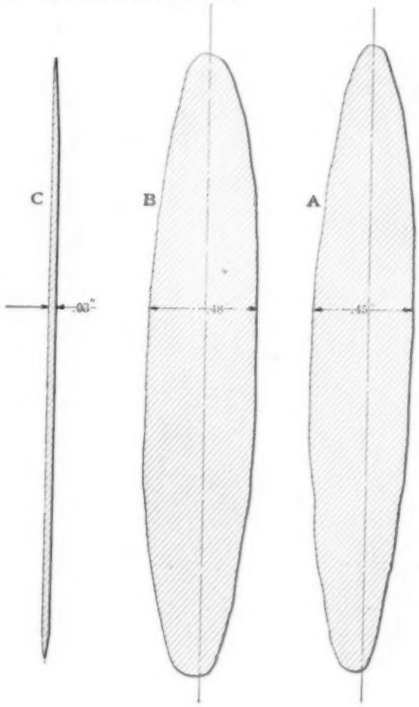


FIG. 5. CLOSED CURVES, SHOWING VIBRATION OF 24X36-INCH JAW CRUSHER BEFORE AND AFTER BALANCING

to a puzzling question regarding two rock houses built substantially alike and equipped with similar machinery, one of which was remarkably free from vibration while the vibration of the other caused alarm. There was a tendency to lay the blame on constructive details, but the trouble lay unsuspectedly in the crushers. The two crusher flywheels are about 5 feet in diameter and weigh over two tons each. They are good looking wheels turned on the face and apparently symmetrical, but they are not balanced, nor properly unbalanced. A pair of such wheels were found to be out of balance 75 pounds at a radius of 2 feet and these were probably nearer right than most of the wheels found on such crushers. If the wheels are so placed on their shaft that the unbalanced weight comes in the right phase, as demonstrated, it is evident that the shaking will be reduced, and if the unbalanced weight is great enough they may run very steadily. However, the same weight may as likely be on the wrong side and accentuate the difficulty. Apparently in one of these houses the accident of flywheel unbalancing was a benefit, and in the other a magnifier of trouble.

A Test and Its Results

To test the above analysis a 36x24 crusher was mounted on a truck resting on a railroad track so that the crusher and truck could vibrate freely as the jaw moved. A small vertical engine mounted on the crusher furnished a self-contained driving mechanism. An indicator was fastened to the crusher frame so that the axis of the paper cylinder was parallel to the movement of the truck.

The paper drum was made to oscillate in phase with the pitman, but with a motion magnified by a crank on the end of the shaft. A pencil held rigidly from the floor would draw a curve on the paper, the length of the curve being the drum movement or enlarged eccentric travel, while the width of the inclosed figure would give the amplitude of the vibration of the whole mass which weighed about 45 tons.

When the crusher is run very slowly the shaking force will be small, and the movement of the mass, therefore, small, also at some very high speed while the shaking force will be large the time the force persists in one direction is so short that the amplitude of movement may also be small. Somewhere between these two extremes is a speed giving the maximum linear movement. This evidently depends on the mass to be moved as well as on the stiffness of the building.

Some makers recommend that the crusher be run at a relatively high speed which might reduce the vibration, but the trouble is to get up to the high speed without going through the speed of maximum shaking where the vibration may do serious damage. Each building of this sort has a natural period of vibration which if it coincides with the crusher vibration, greatly amplifies the forces, and this critical speed is likely to be caught somewhere in the range of getting up speed to the high limit recommended. The particular crusher mounted on the truck seemed to give the maximum vibration at about 50 revolutions per minute. Fig. 5 shows the diagrams taken at this speed. For the crusher as originally put up the vibration is shown at A, and was 0.45 inch. The shaft and wheels were then taken off and so well balanced that ¼ pound on the rim would show them to be unbalanced on the testing ways.

When the machine was run with these well balanced wheels the curve *B* was the result with a vibration of 0.48 inch. Two counterweights as figured were then properly placed in the flywheels, and when run curve *C* showed the vibration to be reduced to 0.03 inch.

In the diagram Fig. 4, if we combine the curve *R K' S* and *T K T'* we have the resultant curve *W Y Z*. This shows that the shaking forces have been greatly reduced and their alternations have been doubled so that the smaller force also has a shorter time to produce movement before reversal.

This resultant *X Y Z* shows that a nearly complete balance could be had by adding to the single rotating weight here described a second weight rotating at twice the revolutions per minute of the main eccentric. If the inertia of this secondary weight was made equal and opposed to *O W* the final resultant would be nearly a straight line. The secondary weight would have to be geared to the main shaft with a gear ratio of 2 to 1, making a complication of parts not warranted or needed in the usual crusher installation, but still of possible value in extreme cases.

It is now feasible to run crushers of this type at any reasonable speed without the danger of racking the building or requiring unusually heavy construction to resist useless forces.

Recent months have seen a decided decline in the price of platinum due to a decreased demand, and as a result the prevailing price is $20 an ounce against $40 an ounce a little over a year ago. Aside from its use in the jewelry trade, which has been increasing of late years, platinum is largely consumed in electrical and photographic supply manufacture, and the dental profession has also found considerable use for it, principally in the manufacture of plates for artificial teeth.

Gas Engine Piston Pins

By N. C. Hildreth

Probably upward of eighty per cent. of the gas engines made in the United States have the piston wrist pins stationary in the pistons and oscillating in the connecting rods, in the smaller units the rods having fixed bronze bushings which in some cases have means for adjustment to compensate for wear. To many it will come somewhat as an innovation, therefore, to learn that a few of the larger automobile manufacturers and an occasional marine- and stationary-engine manufacturer some time ago adopted the practice of oscillating the piston pin in the piston, having it fixed in the connecting rod, and the results have been so satisfactory as to justify the change from the older and more common method.

I do not know who was the originator of this oscillating-pin method nor how long it has been used, the earliest practice of which information is at hand being that of one of the smaller two-cycle marine-engine manufacturers who about 1904 made his motors with the piston pin oscillating in either or both the piston or connecting rod, it being fixed in neither, and secured from end movement by a groove turned around the piston pin midway its length and in which a pin driven into the connecting rod loosely engaged. A little thought will show that this method is wrong in principle and not worthy of adoption as a whole, although it has been used in auto-engine construction to some extent since that time. With the pin-fixed-in-piston method it is impossible to secure sufficient pin diameter to make adequate wearing surface because of the room in the piston being limited and occupied to a large extent by the bronze bushing and adjusting device. It is also very difficult to adequately lubricate a pin of this construction because of its inaccessibility. These two vital weaknesses make this construction short lived especially in the higher speed auto and marine motors, and it is open to the further objection that the retaining screws or pins used to secure the piston pin occasionally work out and fall into the crank case causing serious breakage, or allow the piston pin to work over against the cylinder wall scoring it badly and necessitating reboring. The advantages of oscillating the pin in the piston are:

1. Increased bearing area, due to the fact that the bronze bushing in the connecting rod is eliminated and the space formerly thus occupied can be added to the piston-pin diameter increasing it approximately fifty per cent., and also to the increased length of pin bearing made possible by the smaller portion fixed in the connecting rod as compared to the two portions fixed in the piston under the old method.

2. More perfect lubrication of the pin bearings for reasons which are obvious.

3. The better opportunity for adequately securing the clamping bolt. Actual comparative trial of the two methods has demonstrated the greater durability of the oscillating pin method even when the pin wears directly on the piston casting as shown in the drawings. If the piston-pin holes are bushed with hardened and ground steel bushings pressed to place and adequately retained as is done in the highest grade automobile construction, every argument and point of superiority lies with the later method as even the matter of renewals costs no more with the new method than with the old.

In the accompanying drawing, Figs. 1 to 3, give a clear idea of the application of this method to a gas engine of four and one-half inch bore and while it may be objected that the construction is too light for stationary engines, as a matter of fact the refinement of automobile-engine design during the last three or four years has so modified old ideas that recently designed stationary engines of both vertical and horizontal types weigh only about one-half as much as ten or even five years ago for the same developed horsepower. The accompanying table gives piston-pin dimensions for cylinder bores from three and one-half to six inches in diameter. These dimensions are subject to modifications and are suggestive rather than arbitrary. The pin diameters are fixed with a view to using stock sizes of steel tubing. As will be seen by reference to Figs. 2 and 3 the pin is secured from end movement by the clamping bolt *H* engaging in the groove *G* and *H* is prevented from turning by the cotter pin against the connecting rod. It will be observed that this method contemplates the use of drop-forged-steel connecting rods which are required by the necessarily light construction, the heavier proportions demanded for adequate strength when rods are made of either bronze, malleable iron or steel castings, making the use of any of those metals un-

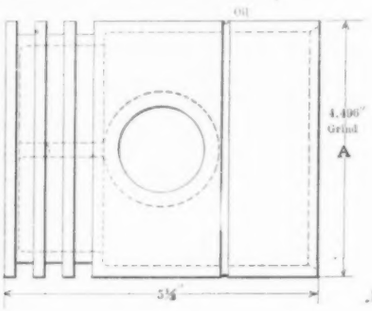


FIG. 1

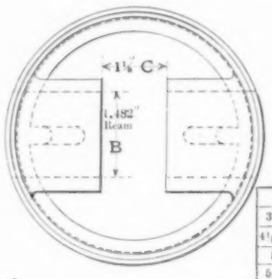


Table of Sizes in Inches

A	B	C	D	E
3½ to 4	1.53	⅞	1.215	30/64
4¼ to 4½	1.482	1⅛	1.46	17/64
5 to 6	1.723		1.72	
5 to 5½		1⅛		1⅜/64
5¾ to 6		1⅛		1⅜/64

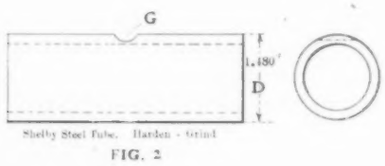


FIG. 2

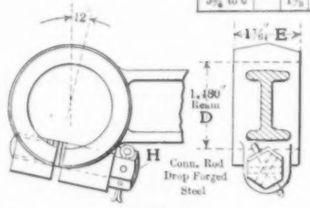


FIG. 3

GAS ENGINE PISTON AND PIN

desirable if not impossible. It is believed that a careful consideration of this method of construction will prove of interest to all manufacturers who are not familiar with it and be of profit to those who decide upon its adoption.

Some More Antique Machine Tools—Number 3

By E. A. Dixie

Fig. 9 shows what is supposed to be the eldest turret lathe in America. Who built it or when it was built no one knows, but it was among the first tools in the Gay & Silver shop; possibly it was not new when they bought it.

It is still known in the shop as "the set screw machine" as that was its job for many years. The turret has 6 holes and is locked by the plug with a hand wheel on the end of it. The pilot wheel spindle carries a pinion which engages with a rack on the turret slide. Stops are provided at the back of the machine for controlling the movement of the turret slide.

The cross slide has two tool holders and the carriage has a nut which engages with the lead screw in front of the bed. The spindle is hollow and has a chuck on the nose, while the rear end is provided with 8 set screws to keep the stock central.

The lubricant was kept in a barrel on the floor above and fed by gravity down through the pipe which is shown in the illustration. The handle at the extreme left worked the belt shifter. Fig. 10 shows another turret lathe with horizontal turret. In this case the rack is secured to the bed and the pilot-wheel shaft is journalled in the turret slide and moves with it. The carriage has a rack secured to it, the end of which can be seen projecting beyond the headstock between the spokes of the large hand wheel. This rack engages with a pinion on the shaft to which the large hand wheel is attached. The cross-slide is equipped with two tool posts. This machine has for many years been used for machining castings for flyer noses used in spinning frames and is, for that reason, called "the flyer nose machine." Of the age of this machine there is no record, it probably dates back to the opening of the shop.

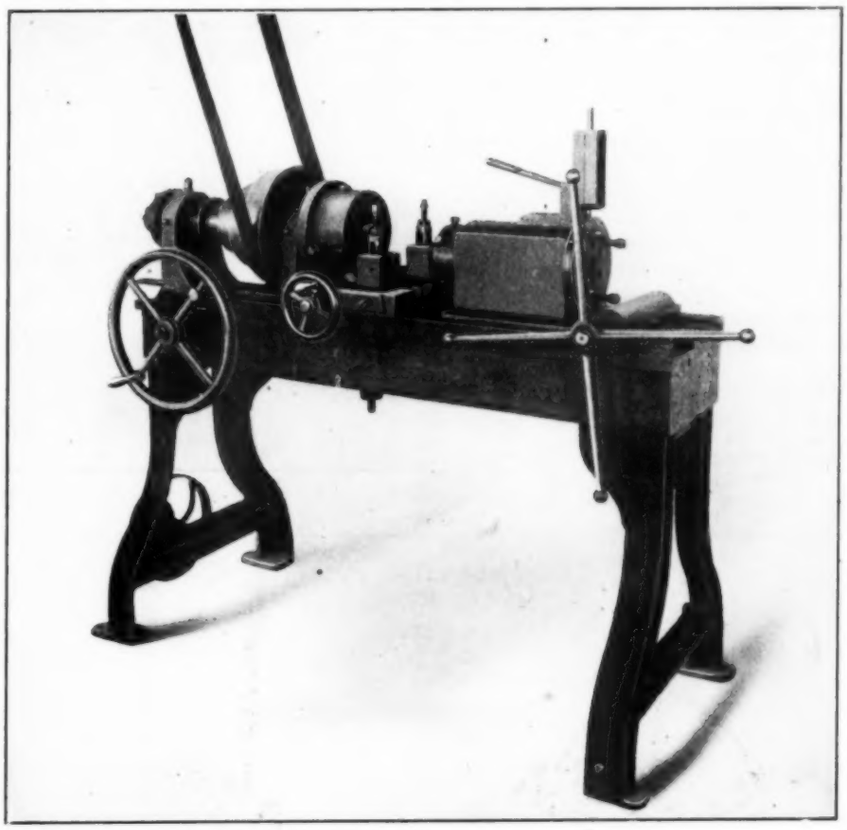


FIG. 10. OLD HORIZONTAL TURRET LATHE

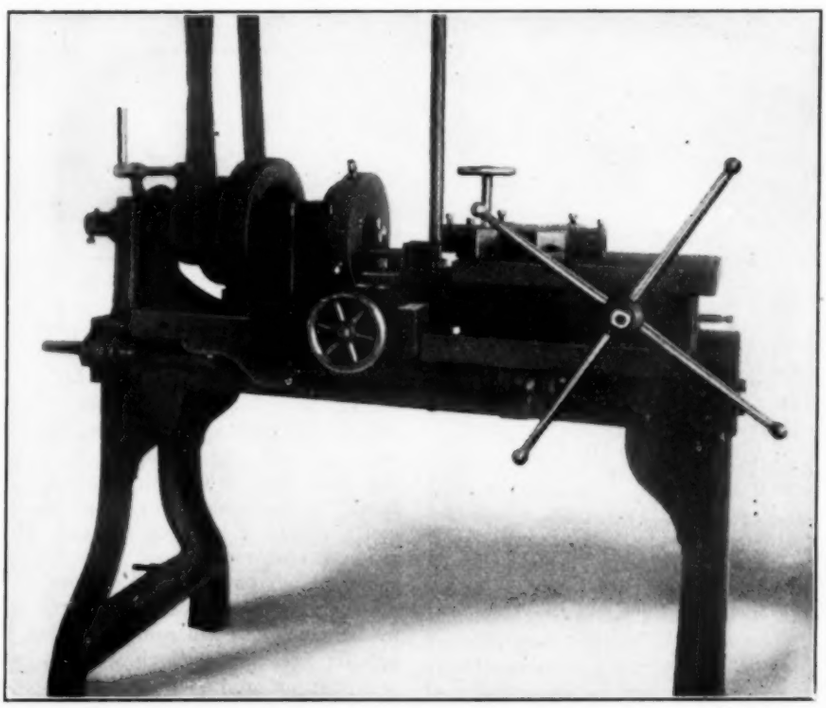


FIG. 9. FIRST TURRET LATHE IN AMERICA

Fig. 11 shows a drilling lathe built away back in the early days. The tail spindle is square in section and has a rack cut on its upper face. The rack engages with a pinion on an intermediate shaft which carries on one end a gear which engages with a pinion on the hand wheel shaft.

The carriage is of the weighted type with rise and fall. It is actuated by a chain connecting with gearing driven by the spindle. Part of the chain is visible between the shears of the lathe just below the tail spindle rack.

In this lathe the drill can be held either in the chuck on the head spindle or on the tail spindle.

Fig. 12 shows a very old lathe. The bed is of wood with cast iron ways screwed to it. It was built for a boring lathe to use flat drills. The head spindle is equipped with a three jaw scroll chuck. In front of the head is a spring stop which enters holes on the body of the chuck, holding it while the operator moves the scroll with a spanner wrench. It is said that Mr. Silver made the first scroll

chucks manufactured in this country, which I suppose means the first made anywhere. The tailstock is, to say the least, peculiar in design. The tail spindle follows a design very common at one time. The method of clamping the tailstock to the bed, by means of the double ball lever and long bolt passing through the tailstock bottom to the clamp between the shears is but a more clumsy form of the tailstock clamp used in some modern lathes and considerably more efficient than some of those having an eccentric and lever. The tailstock sets over. The guide for the flat drills shown between the headstock and tailstock is quite a handy rig for the purpose. The line cut Fig. 13 shows the construction. *A* is the body bolted to the shoe on the lathe bed. *B* is the lower jaw of the guide, pivoted at *C* to *A*. *D* is the upper jaw tapped for the set screws *F* and having an elongated slot for the stud *G*. *G* is secured in *A*, passes up through the elongated holes in *B* and *D* and is provided with a halfball washer *I* and nut.

The lower jaw *B* is adjusted for hight by the screw *E*. The slot *H* is adjusted by means of the set screws *F* so as to be a loose sliding fit for the body of the flat drill. The flat drill, by the way, is a very efficient tool in the hands of a man who knows how to use it and the reverse in the hands of one who does not. For the benefit of those who have not used flat drills it is perhaps as well to mention that the rear end of the drill has a fairly large

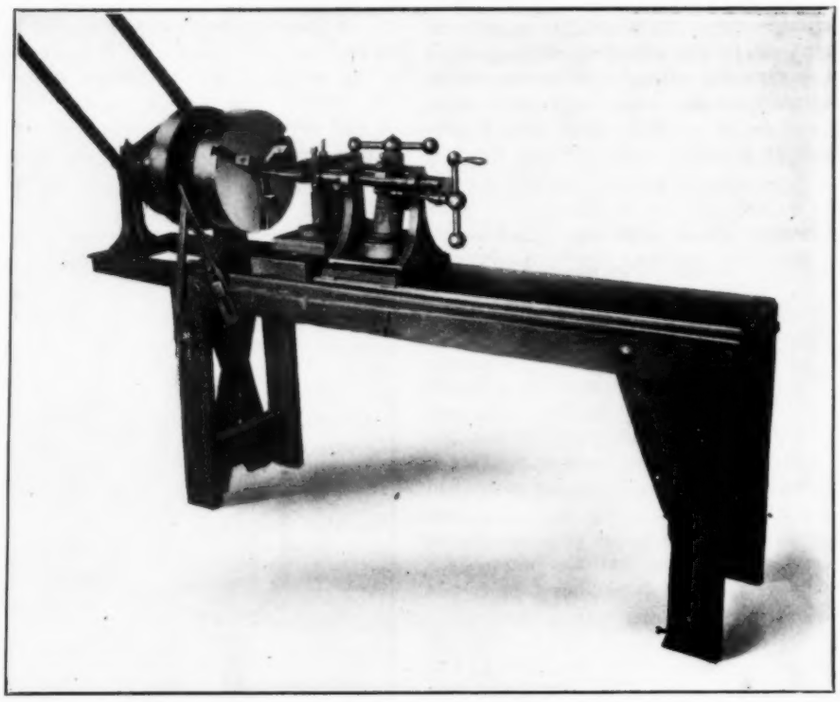


FIG. 12. THE OLD BORING LATHE

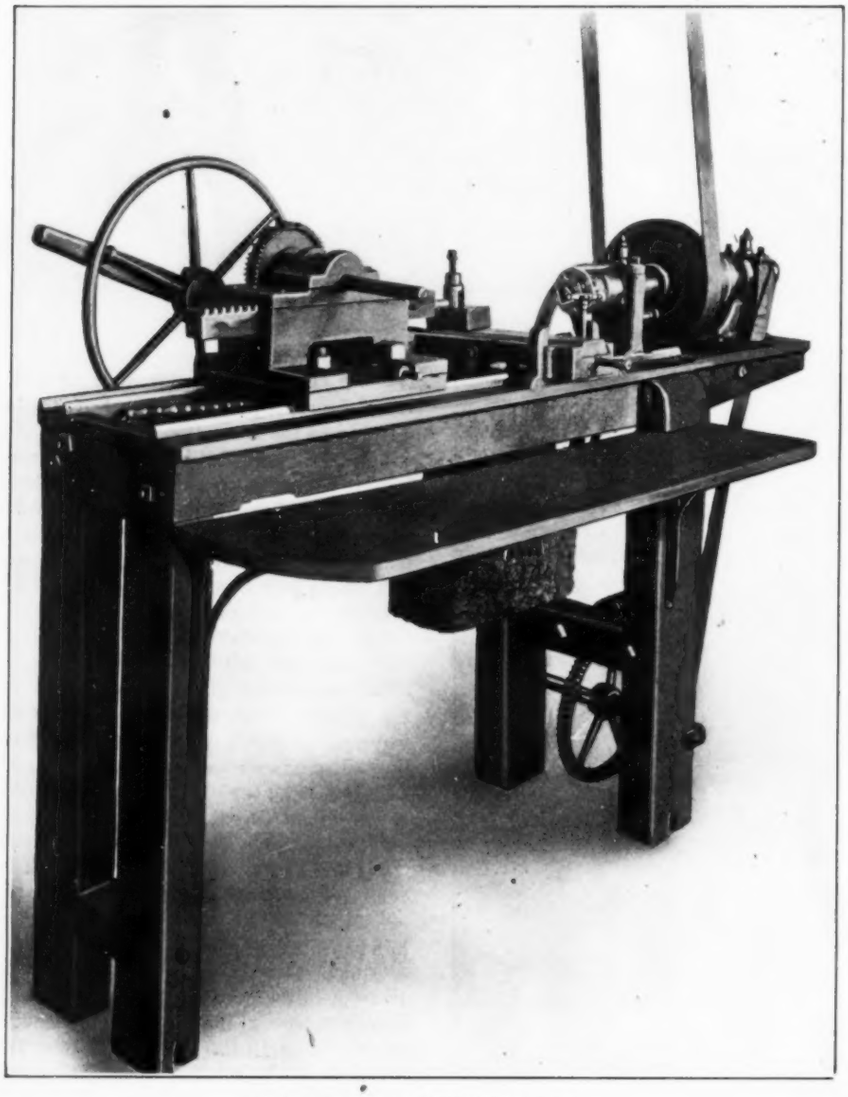


FIG. 11. THE OLD DRILLING LATHE

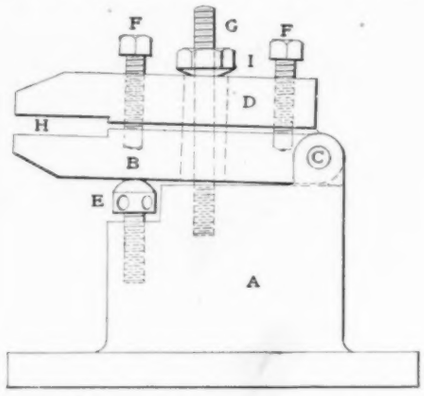


FIG. 13. THE FLAT DRILL GUIDE

center in it which bears on the tail center. A strain is kept on the drill in the same direction as the cut either by a monkey wrench held in the hand or better still a hook made of round iron, the hook being of such size and shape as to grip the drill (just behind the guide). The handle of the hook is say 18 inches long and a weight is hung on the end, which projects horizontally, and thus keeps a steady strain on the drill without tiring the operator. The feed is, of course, done by advancing the tail spindle. When the hole is breaking through a little extra weight is put on the lever so as to prevent the drill pulling through and either displacing or breaking something.

Making Pliers of Various Kinds and Sizes

Including Novel Methods of Drilling, Slotting, Grinding and Hardening, Together with Interesting Details and Special Features of New Shop

EDITORIAL CORRESPONDENCE

The buildings of the Utica Drop Forge and Tool Company, Utica, N. Y., have a peculiar interest aside from their structural features. The old plant was destroyed by fire on June 25, 1907, and completely wiped out. Instead of discharging all the men, the company kept all who desired on the payroll at the same rate as before and started them at work on a new building. The plans had already been drawn by Mr. Kellemen and work was started at once. Foremen, toolmakers, bookkeepers and helpers all turned themselves loose at digging, mixing concrete, unloading canal boats, building forms for concrete wall, exercising the wheelbarrow and all that goes into the building of a shop with concrete walls.

As a result every man in the shops feel a proprietary interest in it and the first question that is asked by every one of them as soon as he gets a chance is, "What do you think of our shop?" If anyone is interested in shop pride and loyalty this is the place to see the A-1 brand on tap at all times.

And they have a reason to be proud of it. There isn't a dark corner anywhere, the ventilation is good, the shop is kept clean and is comfortable in every way, and they built it. Who wouldn't take more interest in a shop that they had helped to build from the ground up?

I don't know whether the building cost more than a contractor could have built it for or less. The men were not skilled in that line of work and some of them received foremen's wages for doing laborer's work at times, but on the other hand there was no contractor's profit to be paid and no chance or reason for skimped work.

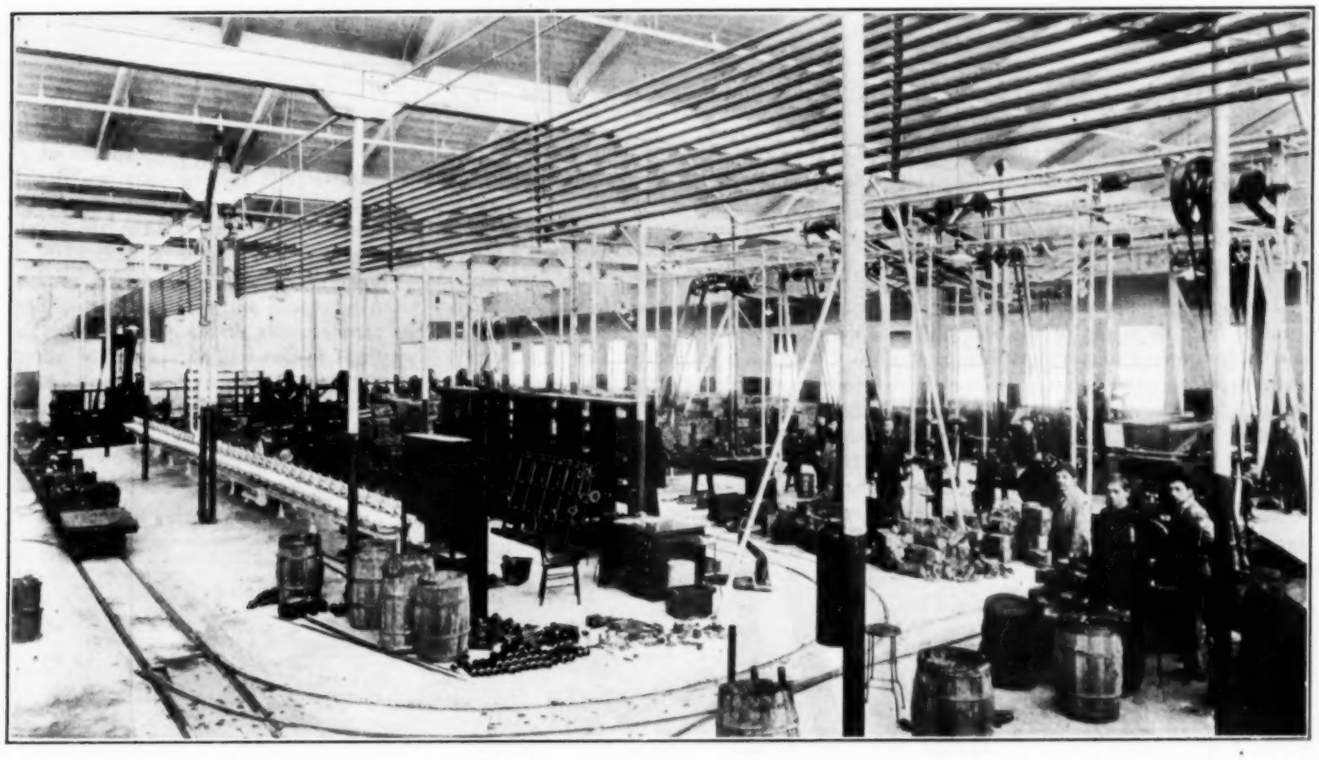


FIG. 1. A GENERAL VIEW OF THE INTERIOR

But whether it cost more or not, it was a good investment in many ways. It kept the organization together so that all the men who were skilled in their particular branch of the business were ready to make pliers as soon as the machinery was in place, without any breaking in. And it produced a feeling of loyalty, a good fellowship and a general air of satisfaction that is hard to find and cannot be excelled in any shop I know of. And with it all there isn't a trace of patronizing anywhere, just a providing of a comfortable and sanitary place to work and fair treatment.

Some Details of the Buildings

The building is 18 feet high under the main beams, this being necessary in the forging shop and contrived to give air space and a uniform appearance. The floor and foundations are of concrete and while wooden mill construction had to be used to get the building under cover before winter, the walls can be replaced by brick or concrete at any time without interfering with the work in the shop.

The building does not face due north, but turns just enough toward the east so that no sun gets through the skylights after ten or eleven o'clock and there is no need of curtains here, although the side windows are well provided for. The roof windows do not open, but the side windows can all be opened at will. The roof ventilation is controlled by thirty-six 30-inch ventilators at the top of the saw teeth. In the forge department, long telescope pipes drop down from these ventilators so that the heat and gas can be taken directly away from the operator, and in this case the draft is aided by a blast from the blower. One of the ventilating pipes with the hood is seen in Fig. 11.

Fig. 1 gives a general idea of the shop and shows how largely wrought-iron pipe entered into the construction. The col-

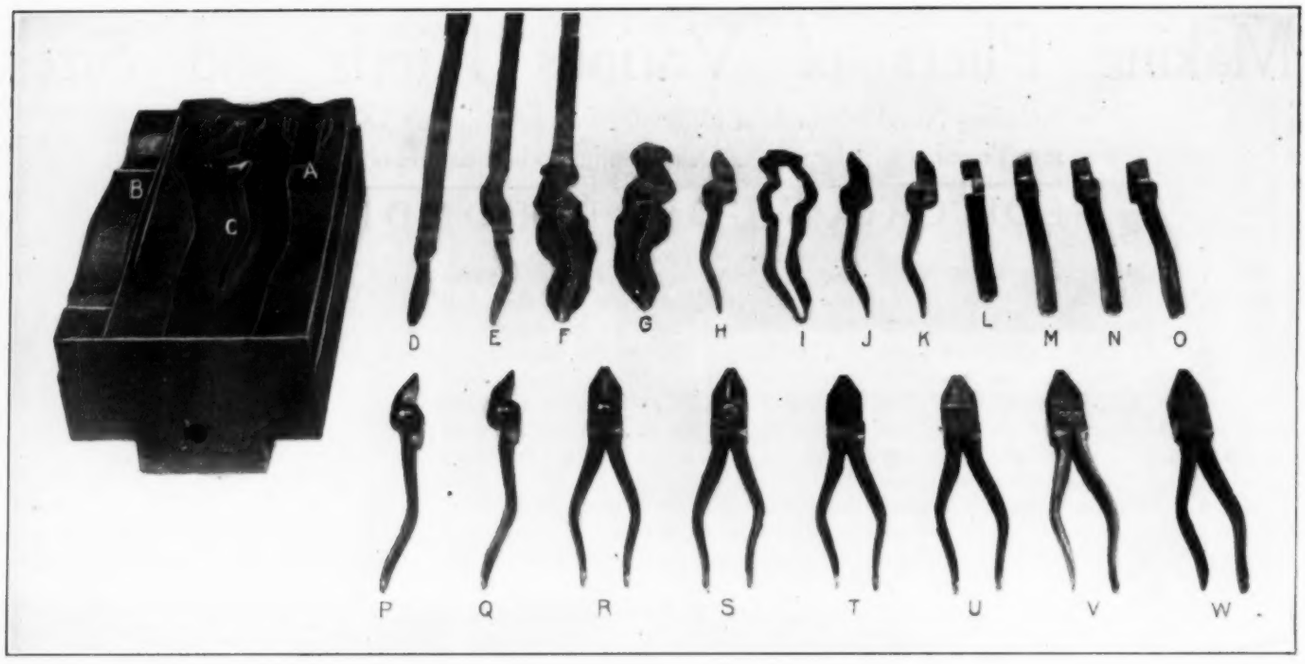


FIG. 2. MAKING THE SIDE-CUTTING PLIERS

umns filled with concrete and all cross and angular braces are of pipe. The countershafts are all hung from pipe-work supports. These supports are set in the concrete and steadied from above by the angular braces shown.

The heating pipes are located near the roof to keep them out of the way and to melt any snow as soon as possible, as this is a snow country and the sooner it is melted the better. They report no trouble in heating the shop down where the men are.

One of the features most in evidence is the Hunt industrial railway with its storage-battery locomotive and train of flat cars which handle the material in all its stages.

Forging the Pliers

Those who are familiar with drop forging work will recognize the various steps shown in Fig. 2 but to others a brief outline may be of interest. The upper die is shown at the left and the bar is first forged down by a few strokes at *A*. When the end is drawn out to the right length, as at *D*, it is placed in the depression *B* and one stroke leaves it as shown at *E*, ready to go in the main die *C*. A few strokes here forge it into shape as at *F*, the surplus metal going out in "flash." After cutting-off as at *G* it goes through the trimming die to remove the flash, leaving it as at *H* and the flash as at *I*.

Similar operations are shown in Fig 3 on the staple puller which has a number of interesting details. In this case the handle is forged straight as will be noted, as the results seem to be better and the curve is not given until after the trimming as shown at *J*. This is done in a drop press.

Both of these views show the sequence of operations, all being interesting in

FIG. 3. STEPS IN MAKING THE STAPLE PULLER

FIG. 4. SUBMERGING THE WORK IN SODA WATER

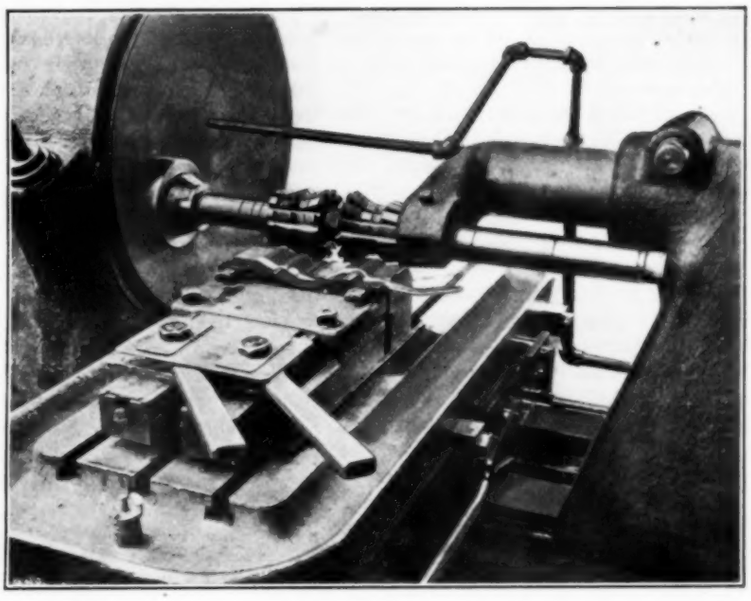


FIG. 5. TWIN MILLING OPERATIONS

some way or another. When these are forged a slight depression in the die leaves a small raised spot as can be seen best in Fig. 3, which is in the center of the bearing portion and serves to locate the blank in the die under the punch press for punching out the rivet holes. This is rather interesting as the punch is simply a piece of drill rod, cut square at the ends and hardened so as to be used on either end. These punches do good work, a 5/16-inch punch going through ⅜-inch steel without any trouble whatever. The plier jaw is now as at *J*.

Submerged Drill-press Work

The counterboring as at *K* comes next and this brings in a method of lubrication that is unusual but very efficient. In Fig. 4 a cast-iron pan is provided for the drill-press table. It contains a guide or jig for the work but this is covered by the drilling lubricant which nearly fills the pan. The operator places the work in position by the sense of feeling, the cutter is run down through the lubricant to the work and there is never any question about the cutter getting enough of it. There are many other places where a similar plan might be used to advantage.

The milling operation comes next and Fig. 5 shows a new machine of a not very common type, which has just been installed for this work. Two jaws are milled at once, but one is milled on the back, the other on the front. Both are located by pins and clamped independently by the cam levers shown. This machine has an automatic feed and, after tripping at the end of the stroke, has a quick return to the starting point. The hight of the spindle from the table is regulated by rolling the head with the worm shown at the extreme left. This was built in the shop, being an improvement over others in use there.

Slotting and Shaping in a Punch Press

Then the jaws are corrugated, the depression milled near the hinge for the cutting portion of the jaw, as shown in *M*,

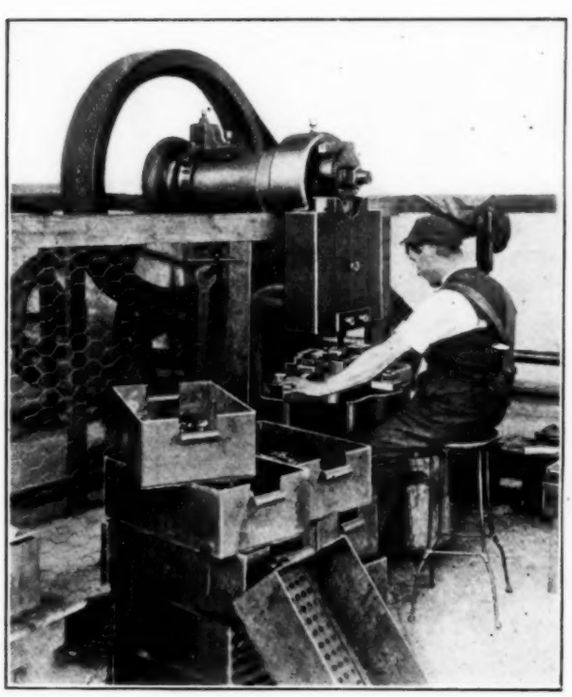


FIG. 6. A PUNCH-PRESS SLOTTER

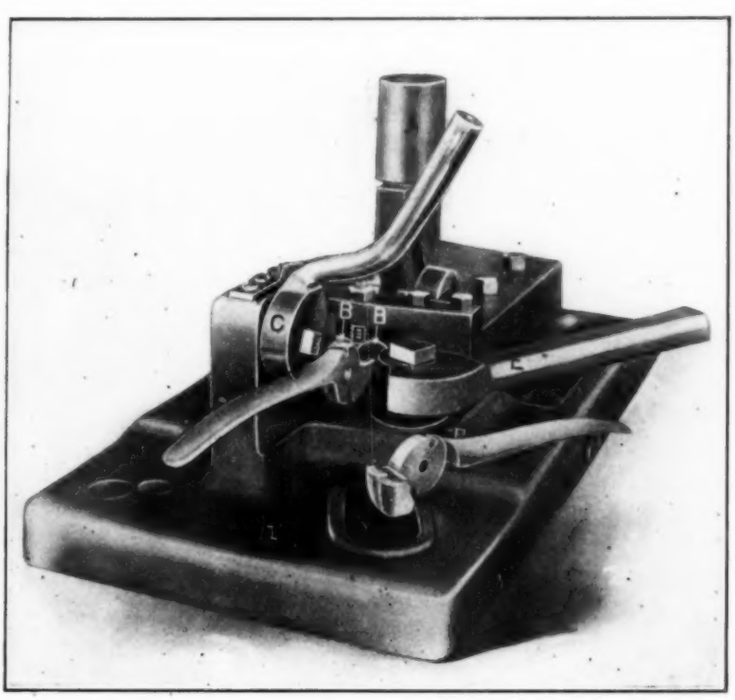


FIG. 7. HORIZONTAL SLOTTING ATTACHMENT

N and *O*, Fig. 2. This is worked out to the shape shown at *P* by an ingenious transformation of a punch press into a slotting machine, as shown in Fig. 6. The jaw is clamped in the vise shown, and the vise jaws fed along under the punch by the handle at the left. A stop insures the proper length of cut each time.

This same press is converted into a horizontal slotter by a very ingenious fixture, shown in Fig. 8. Here the upright plunger *A* fits the punch holder of the press and moves up and down with it. The lower part of this has an inclined slot which moves the slotting tools *B B* in a horizontal direction. This is for cutting out the jaws on the staple pullers, one jaw being shown on the fixture. The rivet hole is slipped over a pin clamped by the lever *E*, and the jaw fed up to the shaping tools by bringing down the cam *C*. The jaws come up against a stop *D*, which is between the cutting tools, and so secures an even depth of cut on all the jaws.

Next comes the counterboring, putting together and riveting, as in *Q*, *R* and *S*. The riveting is done on the machine shown in Fig. 8. These were formerly held in both hands, which brought the fingers holding the jaws rather close to the riveting hammer. So close in fact that the operator occasionally found himself minus a few pieces of finger. So he devised the guide at the back and now sticks the points of the jaws in this and keeps his fingers at a safe distance. This increased his output so that, in addition to saving court plaster and some fingers, he gets more money out of the job than he did before.

Handy Tote Boxes

Both this view and Fig. 6 show a scheme for tote boxes that has several good points. They are all metal and can not only be used for tote boxes, but also form counting racks when used bottom side up. The number of holes used are 100, 150 and 200, and in addition to aiding in counting it also makes it very convenient to pick up one piece at a time to be operated on. The handles are rolled up sufficiently to allow the hand to get underneath nicely when used upside down. Another kind of rack is also shown on the stool behind the boy.

After riveting they go to the grinding room where the operator at the right of Fig. 9 places them on the rest between the two wheels of a disk grinder and brings the outer wheel up against it with his right hand. This not only grinds off the surplus metal from the rivet head, but also finishes the jaws, as shown.

The left-hand wheel of this grinder has a curved face or side and grinds the ends of the staple puller by means of the fixture shown. The piece drops between two pins in a swivel plate, which is mounted in the trunnions of the fixture. This allows a movement in both directions and gives the head a nicely rounded surface in both directions.

The Box Joint Plier

The regular plier shown is a simple problem as compared with what is known as the box-joint plier and shown in its various stages in Fig. 10. This is not the usual method of making box-joint pliers, but has been developed by Mr. Kellemen after much experimenting.

The box or outer jaw is drop-forged, as shown at *A*, then punched as at *B*,

FIG. 10. STAGES OF MAKING THE BOX PLIER

while a second punching leaves it as at *C*. The inside jaw is shown at *D* and they are put together as at *E*. Then the hammer closes them together as at *F*, and after drilling as at *G*, they are ready to go through the same kind of finishing operations as the others, except that somewhat different fixtures are necessary owing to the two jaws having to be handled at once.

The Steel and Its Treatment

The question of steel to be used is important and interesting. For plain pliers

FIG. 8. RIVETING THE PLIERS

FIG. 9. IN THE GRINDING ROOM

we would be apt to say that low-carbon steel could be carbonized sufficiently to answer very nicely, but as most of the pliers made have cutting edges somewhere in their make-up, we expect to find crucible or tool steel. That's where we guess wrong, for the whole pliers, even those with separate jaws, are made of low-carbon steel, heat-treated to secure the desired hardness at the various points. The points must be tough for twisting, the cutting jaws tough and hard and the rest treated for strength and toughness. It sounds rather like a fairy tale after some of our preconceived notions, but after we see the tests they receive before being finally passed as fit for sale, we cannot but agree that they stand the strains regardless of the material of which they are made.

Inspection

The inspection of the tools is very thorough, every operation on each tool being inspected by girls. During the passage of the tools through the mill they are sent into the inspection department eight different times.

These tests impose all the abuses that the toughest lineman or the huskiest farmer can impose. Neither of these cut wire with a steady pressure, but by gripping the wire in the cutting jaws as tightly as convenient and then twisting or "sawing" until the wire parts or the jaws break. In the tests witnessed the jaws showed no signs of chipping in spite of the abuse of cutting very large wire with small pliers or even of cutting hard-drawn steel rods. It hardly seems possible that steel can be treated to secure such results, but they have the art of carbonizing down to a fine point, and the supt. does not believe it possible to obtain such results with crucible steel.

Fig. 11 shows the carbonizing boxes, ready to be put in the furnace. The small truck makes a very convenient way of putting each box in any particular place you desire, the spade or supporting end swiveling under control of the handle, enabling it to be exactly located at any desired point.

The heat of these ovens is controlled and recorded by the Bristol pyrometers, shown on the wall. These connect with recorders in the supt.'s office so that he has a record at all times of the heats that have been used.

Further operations have to do with the finish of the pliers. They are, of course, buffed and polished for nickel-plating, but the standard finish is obtained by burning oil on the handles after they have been cleaned from the grease of the shop. In doing this the pliers are heated by the rackful in the ovens, dipped in oil, replaced in the oven till they reach the right temperature and then cooled in water. This gives a very pleasing and durable finish that resembles an enamel or japan.

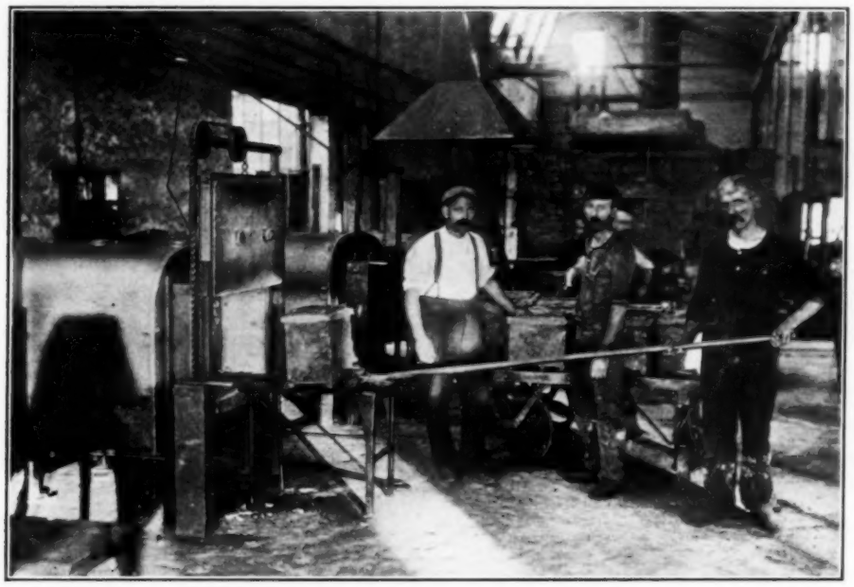


FIG. 11. THE HARDENING FURNACES

In closing it is only just to express appreciation of the kindly interest shown, and assistance rendered by Henry F. Kellemen, vice-president and superintendent and all his assistants. And while only three types of pliers have been mentioned it must not be inferred that this is their complete line, as the number must exceed the well known 57 varieties.

F. H. C.

We turn out over 25,000,000 tons of pig iron every year, and the production for the first half of 1907 was at the rate of 27,000,000 tons. This is two and one-half times the product of Great Britain. It is nearly half the product of the whole world. And the supply of this most precious of all the metals is so far from inexhaustible that it seems as if iron and coal might be united in their disappearance from common life.

Cooperative Course at the Lewis Institute

A plan of coöperation in a course in mechanical arts has just been put into effect by the Lewis Institute and manufacturers in the metal trades in Chicago. Its purpose is to offer boys specialized training and the preparation for work as mechanics and operators in manufacturing industries. Heretofore boys employed in shops who were ambitious to make the most of themselves have been obliged to depend upon night or correspondence schools for supplementary instruction. The necessity for giving such boys a better opportunity to become skilled and intelligent workmen has led to the arrangement herein set forth. The plan is a modification of the Cincinnati University plan, whereby the Lewis Institute proposes to give instruction parallel with the shop training furnished by the manufacturing industries of the city.

Length of Course

As outlined the course is for two years comprising 50 weeks of work and two weeks of vacation. During each year 24 weeks will be spent in the school and 26 in the shop. The students are to be arranged in two groups alternating week by week between the shop and the Institute. The responsibility of the shop training rests with the employers of the boys and the responsibility for the instruction rests with the institute.

Conditions of Admission

The age limit is from 16 to 20 years. A condition of admission is a recommendation of an employer to the institute, or the recommendation of the institute to an employer. The candidate must satisfy the director of the institute that he is prepared to profit by the instruction that will be given and must satisfy the employer that he is capable of doing the work required in the shop.

Wages and Tuition

The employer is expected to pay $5 a week for the time spent in the shop and tuition amounting to $50 a year for each boy, but the boy will receive in addition, to the combined instruction, an income of $2.50 per week for two years. This means that the cost to the employer of one boy is $180 a year, or $360 for two boys who will do the work of one employee for a period of 52 weeks, approximately $7 a week.

The Course of Instruction

The institute gives instruction to the boys for eight hours a day, five days in the week; this instruction to be best suited to their needs. The course consists of instruction two hours a day along each of the four following lines:

1. Physical science and the principles of mechanics.

2. Machine sketching and mechanical drawing.

3. Such shop work as will best supplement the work that the boys are doing when not in school.

4. English, history and mathematics.

Two Shearing Dies

BY ETHAN VIALL

Back in the early days of the safety bicycle, when the selling price of a good machine ranged around a hundred and fifty dollars, but little attention was paid to economical production, nor did the real squeezing come until the price fell below one hundred.

With the price hovering around seventy-five, it became one grand scramble for labor-saving devices and short cuts. Stampings took the place of machined forgings in some cases, and various other changes took place.

It was during this wholesale digging after short cuts that the two dies which I am about to describe, were evolved, and possibly they may be of use to someone for other classes of work, since they are so extremely simple.

The firm for which I was working was making a line of cones similar to Fig. 1

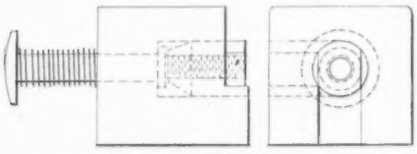


FIG. 2 Die

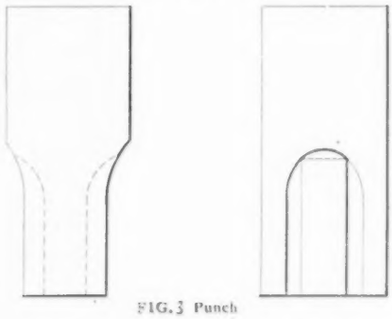


FIG. 3 Punch

FIG. 1 Cone

PUNCH AND DIE FOR CONE SHOWN

and these cones were made on an automatic screw machine, from round bars of cold-rolled steel. The automatics, turned, tapped and cut off the cones, leaving nothing else to be done on them, but to cut in the wrench holds, and harden them.

Probably a few years earlier the firm could have afforded to rig up a milling machine and mill the flat wrench holds on them, but they certainly couldn't and wouldn't then, so we made a punch and die to shear out these places and Fig. 2 shows the side and end views of the die. It was made of a solid block of tool steel and set into a cast-iron plate.

The cones were slipped into the hole in the die, sheared off and knocked out by hitting the plunger with one hand.

In Fig. 3 is seen the shearing punch used. This punch was made of one piece of round tool steel and was milled out, after which a slight clearance was scraped in by hand. Two sides were made alike, so that when one side became dull the punch was turned around.

At first a bevel was ground on the cutting edges, but we soon abandoned that and ground the punches perfectly flat on the bottom. This gave us just as good results in the work and the edges didn't chip off so much.

Nothing was used to hold the cones except the friction of the hole, but they had no tendency to turn and break the punch, as we at first feared they might.

A set of punches and dies was made for each size of these cones and these were used for three or four years.

Another class of cones made by this firm, were also made from round bars of cold-rolled steel on automatics, but owing to the shape, they had to be sheared for the wrench holds in another style of die.

The shape of this cone is shown by Fig. 4 and Fig. 5. It was made from a flat piece of steel which was slotted as shonwn. A flat spring stop, with a big

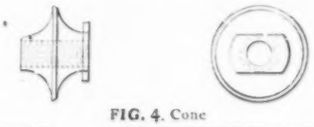


FIG. 4. Cone

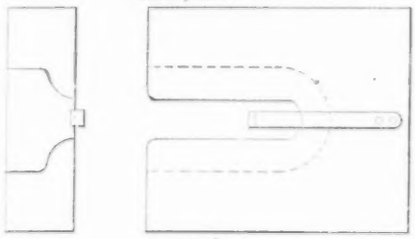


FIG. 5. Die

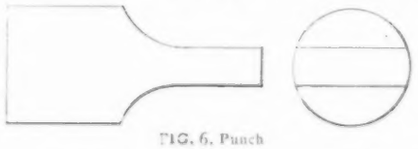


FIG. 6. Punch

PUNCH AND DIE FOR CONE SHOWN

end, was used to prevent the cones from being shoved in too far.

The cones were simply slipped into the slot in the die, with the thin flange of the head on top, and then shoved down through with the punch shown by Fig. 6, a hole in the bed plate letting the cones drop down into a box.

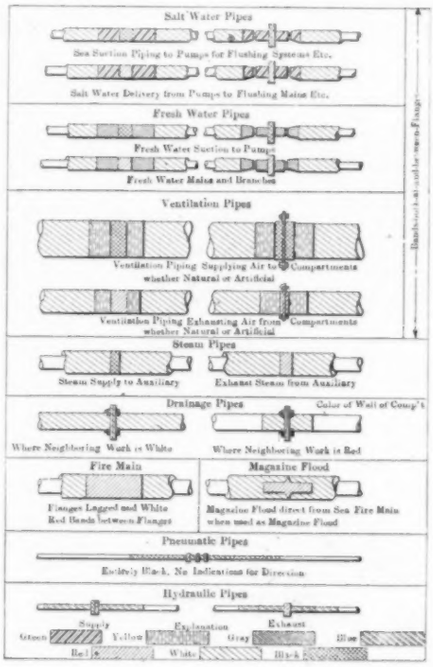
As will be readily seen the punches and dies were very easily made, scarcely any hand work being needed and very little steel used.

So smooth was the work of these tools when kept sharp, that except for the few that were nickel-plated, none of the cones were polished, but were simply case-hardened, ground a little on the bevel face, and sent out.

Pipe Markings in the American Navy

BY A. H. NOURSE

The accompanying engravings and notes show the markings of the various pipes on United States war vessels.



PIPE MARKINGS IN THE UNITED STATES NAVY

Outside of machinery spaces all pipes, except pneumatic pipes, are painted white (the general color of neighboring work). The contents of each pipe is indicated by distinctive color bands placed upon the flanges, or at intervals between the flanges, or in both places, as shown opposite.

The valves also are painted distinctive colors, indicating the contents of the pipe.

The direction of flow of the contents of the pipes is indicated by a narrow color band (red or black) painted around the center of the band that indicates the contents of the pipe.

In general, the narrow black band indicates the flow toward the motive power of the system, or toward an auxiliary, and the red band indicates the flow away from the motive power or auxiliary. Except ventilation pipes in the coal bunkers, under the fire and engine rooms and storeroom floors in double bottoms and wing passages, all pipes are painted the color of the compartment and retain their distinctive bands as given opposite.

Tests of Milling Machines and Cutters

Guarantee for Power Is Needed; Feed Mechanism Must Be Efficient to Avoid Destructive Wear; Cutter Efficiency Increased by Proper Design*

BY A. L. DE LEEUW†

The design of standard machine tools was for many years, and has been until quite recently, a matter of practical experience, judgment and intuition, and might as well have been called guesswork. Special tools of unusual magnitude were built on somewhat more scientific principles, and this, perhaps, simply because the required dimensions were quite out of the scope of the designer's experience. It was not quite so easy to show judgment about a 6-inch as a 1½-inch lead screw; and it would not have done at all to make the screw 12 in. just to make sure; though the instances are not at all rare when some machine part, screw or shaft, on some smaller machine was made double the required size, simply to be on the safe side.

This condition was not due to ignorance on the part of designers or inability to apply engineering data, but to the fact that such data did not exist or were not public property when they did exist. Further, there was no inducement for the machine-tool builder to spend time and money collecting data, as the tools, as built, filled all requirements to a reasonable extent.

This condition ceased to be satisfactory with the coming of the electric motor into the field of the machine-tool builders. At first the wildest and most varied guesses were made as to the size of motor required to drive a certain tool. One builder would supply his machine with a 2½-horsepower motor, while another would equip the same size and style of machine with a 15-horsepower motor. This chaos was made worse by the fact that most purchasers of motor-driven tools would specify the size of motor to drive the machine. One user would condemn the machine-tool builder because the 10-horsepower motor was entirely too small and the next one because a 5-horsepower motor was much too large, for the same machine.

This brought before the machine-tool builder the fact that a machine was not always used to its full capacity and was sometimes badly overloaded. In sheer self-defense the machine builder was compelled to determine for himself the proper size motor to be put on his machine, and he began to make tests and collect data. Crude as most of these tests were, they laid the foundation for a reasonable method of machine-tool design.

Before some semblance of order was created out of this chaos, a second disturbing factor made itself felt: high-speed steel.

Measure of Machine-tool Performance

The first attempt of the machine-tool builders was to determine the proper size of motor for a given tool. The difficulty they met was to determine when a thing was proper. The substitution of a motor for a belt was not the simple matter it looked. For years past machine-tool designers almost uniformly credited a double belt with a pulling power of 50 pounds per inch width. Tests showed that a belt would do twice and even three times as much, though this was bad practice as far as the belt itself was concerned. Another factor in the calculation of the horsepower was the speed of the belt; but what was the speed, when the cone had four or more steps and the countershaft two or more speeds? And even if the belt power could be calculated, was this the proper power for the machine? Would the machine stand all that the belt would stand? Or again, was the driving power all the machine would stand? In other words, was there a proper relation between power and rigidity?

This showed the necessity of establishing some standard which would be a measure for the performance of the machine, a basis for calculating the size of motor or other source of driving power, and a gage to which the different functional parts of the machine could be proportioned. At first the pressure at the tool point was taken for this standard. A lathe would be specified as able to develop and stand a pressure at the tool point of, say, 6000 pounds; a planer was to have a pull at the table of 20,000 pounds, etc.

This might have been a good standard if it were possible to determine the pressure on an ordinary machine. Tests were made to find the pressure required for various cuts, but these tests required a special arrangement of tool post and could not be taken without modifying the construction of the machine. Experiments showed marked differences in horsepower required to produce a given pressure at the tool post for a given speed of the work; in other words, the efficiency of a machine of given type and size was by no means a constant. This was no surprise, of course, but had been overlooked in some unaccountable way. In fact, it is being overlooked even now, and the idea seems to be abroad that each type of machine has its constant, expressing the ratio between energy delivered to the machine, and useful work done by it.

The difficulty of determining the pressure at the tool post required for a given

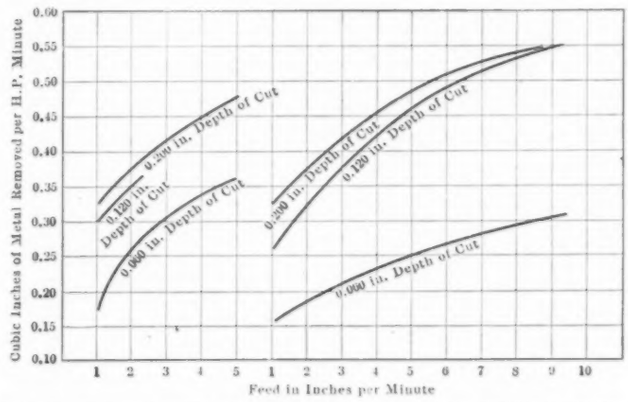


FIG. 1. CUTTING SPEED 12 FEET PER MINUTE

FIG. 2. CUTTING SPEED 32 FEET PER MINUTE

WORK OF 1 HORSEPOWER MINUTE MEASURED IN CUBIC INCHES OF METAL REMOVED, FEED INCREASING

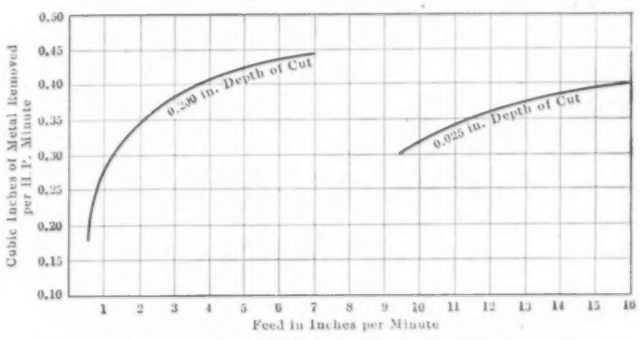


FIG. 3. WORK OF 1 HORSEPOWER MINUTE MEASURED IN CUBIC INCHES OF METAL REMOVED, CUTTING SPEED 45 FEET PER MINUTE, FEED INCREASING

*Condensed from the *Journal* of the American Society of Mechanical Engineers.

†Chief of the designing department, Cincinnati Milling Machine Company.

cut led to the fairly general adoption of another standard, the amount of metal removed per minute. The whole matter is still in an unsettled condition. Specifications for machine tools calling for a guaranteed output are by no means general, but the general tendency seems to be in this direction. It is customary nowadays to call the buyer's attention to the size of driving pulley and width of belt and to the gear ratio, rather than to the output of the machine. This is misleading. Even if actual belt power—that is, the product of belt width and belt speed—were given, instead of size of belt, this would not indicate the capacity of the machine for removing metal; while gear ratio has absolutely no significance except to indicate the reduction in speed which one can obtain in a certain machine. It may be possible that some day in the future machine-tool builders will adopt a set of rules by which to indicate the capacity of a machine, and the first item would doubtless be the amount of metal removed per minute.

Though numerous tests have been made as to performance of machine tools, they have been confined almost exclusively to lathes. All other machines seem to have been considered as following the lathe in cutting characteristics.

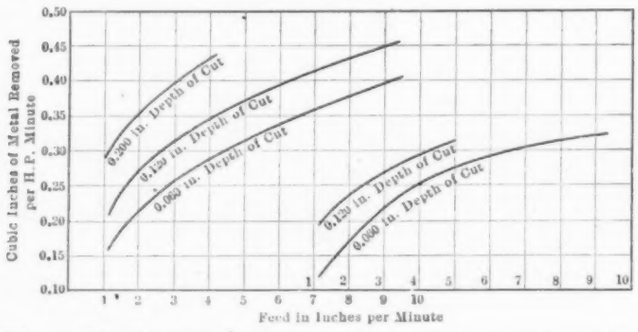


FIG. 4. CUTTING SPEED 67 FEET PER MINUTE

FIG. 5. CUTTING SPEED 150 FEET PER MINUTE

WORK OF I HORSEPOWER MINUTE MEASURED IN CUBIC INCHES OF METAL REMOVED, FEED INCREASING

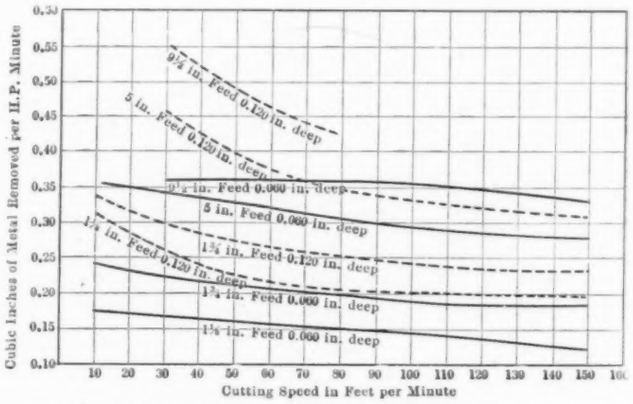

Cubic Inches of Metal Removed per H.P. Minute
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
9¾ in. Feed 0.120 in. deep
5 in. Feed 0.120 in. deep
0¼ in. Feed 0.060 in. deep
5 in. Feed 0.060 in. deep
1¾ in. Feed 0.120 in. deep
1¾ in. Feed 0.120 in. deep
1¾ in. Feed 0.060 in. deep
1¾ in. Feed 0.060 in. deep
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Cutting Speed in Feet per Minute

FIG. 6. WORK OF I HORSEPOWER MINUTE MEASURED IN CUBIC INCHES OF METAL REMOVED, CUTTING SPEED INCREASING

Specifications of Milling-Machine Tests

It was my pleasure to carry out a line of tests as to performance of milling machines, both as regarding feed and speed at the works of the Cincinnati Milling Machine Company. I found available a great mass of valuable data collected during the existence of this firm, but in order to start with a clean slate and unhampered by past experiences, I disregarded for the time being all these as well as all other data within my reach.

The main points to be settled were:

a. How much metal shall a machine of given size be capable of removing?

b. How much power is required for this work on existing machines?

c. Is it possible to improve on the efficiency of present machines and still produce a commercially successful machine?

d. How much power is required for the feed?

e. What is the efficiency of the feed mechanism?

The first question was a point to be decided by the sales manager rather than by the engineer, as it was greatly a matter of competition. As is quite usual in the design of a new line of machines, the desired capacity was placed somewhat higher than that of other makes of similar machines. The customary method is to increase the size of driving pulleys or belt, or the gear ratio, or any combination of these elements. This was not deemed advisable, for two reasons. In the first place, nothing was to prevent competitors from going still further in this matter and so securing a seeming advantage in the sale of their machines without sacrificing anything but a few pounds of cast iron. In the second place, the purchaser of the machine is not interested in the amount of power which he can feed into the machine, but rather in the power of the spindle end, which to him is the business end of the machine. There can be no doubt but that it is better for the user of the machine if he can take a given cut with less belt or motor power. Not only does he save in power, but this power saved is power which would otherwise have been used to wear or destroy the machine.

To determine how much power was required to remove a given amount of metal, tests were made on various machines. The metal to be cut was in all cases, both in these tests and in those to be described later, steel of the following specifications: Combined carbon, 0.16 per cent.; silicon, 0.008 per cent.; manganese, 0.51 per cent.; phosphorus, 0.086 per cent.; sulphur, 0.041 per cent.; tensile strength per square inch, 52,378 pounds; limit of elasticity, 30,313 pounds; elongation per cent. of length, 50 per cent.; per cent. reduction of area, 54 per cent.

The test blocks used were 18 inches long, 5½ inches wide and 5½ inches thick. The ends were milled in to provide means for holding the block on the table of the milling machine. In all tests a spiral cutter with nicked teeth was used, 3½ inches in diameter, 6-inch face, and for a 1½-inch arbor. The cutter was driven by a key, and made of high speed steel. All tests were made by driving the machine by an electric motor, belted to the machine. The object was to have all conditions as near as possible to those under which the majority of milling machines have to run, the only difference being that the belt was nearly horizontal instead of vertical. In testing the efficiency of machines in this way the belt must be considered part of the machine. The power consumed was ascertained by reading of ammeter and voltmeter, and the amount of metal removed by measuring width and depth of cut and the amount of feed per minute. The amount of feed, as indicated on the index plate of a milling machine, is generally an approximation, near enough for every-day work, but not for a test. The actual amount of feed was, therefore, computed from the gearing. In case the feed is a function of the spindle speed, that is, if the feed is expressed in thousandths of an inch per revolution, the feed per minute depends on the number of revolutions per minute of the spindle as well as on the amount of feed per revolution. The exact number of revolutions of the spindle at normal motor speed was determined by computing the gear ratio and pulley ratio. As pulley diameter the diameter of the pulley plus thickness of belt was taken. This computation would give the spindle speed at rated motor speed and without belt slippage. For this reason the speed of the first driving shaft of the machine was determined by the tachometer at each test. All readings were taken simultaneously. The number of revolutions of spindle and the feed per minute were corrected according to the tachometer reading.

Where the feed of the machine was independent of the spindle speed, that is, taken off a constant speed shaft, and therefore, expressed in inches per minute.

the same correction was made, as the amount of feed and, therefore, the amount of metal removed; here again was a function of the speed of the first driving shaft.

These preliminary tests showed considerable differences in the efficiency of different machines, that is, one machine would cut considerably more material than another for a given amount of horsepower developed by the motor. They also showed that the efficiency of all machines was relatively low as compared to the lathe. This latter might have been expected considering the nature of the cutting tool. As the main problem in a machine shop is not to save power, but to get the greatest possible output, this lack of efficiency cannot be held up against the milling machine as a type, for its other peculiarities make it highly efficient as a producer of work.

There was nothing radical or revolutionary in these points, but it was thought that strict adherence to well known principles should give the best obtainable results.

More complete tests based on the result of the preliminary tests were made after the line of high-power millers was developed and completed. These tests were of three kinds:

a Tests determining the amount of metal removed per horsepower.
b Tests determining the efficiency of the feed mechanism.
c Tests determining the efficiency of the driving mechanism.

Power Required to Remove Metal

The same motor and belt were used for all cutting tests. A series of tests was made with a depth of cut of 1/16 inch; then with a depth of ⅛ inch; then 3/16 inch, ¼ inch and ⅜ inch. This complete test was repeated four times. The cutter was sharpened in the ordinary way before starting a complete series of tests, and not resharpened during test.

For each depth of cut a number of different feeds were used. In all cases the even feeds were used starting with the second (next to the lowest) and increasing thus: second, fourth, sixth, eighth, tenth, etc., up to the highest feed. It was, of course, impossible to go through the entire series with the deeper cuts, as the belt would slip before the last feed was reached. This slippage of the belt was at all times the end of the test for that depth, except where the entire scale of feeds could be used. Readings were taken, when the belt slipped; but these readings were not used in plotting curves. They served as a check on the belt tension. It was found that the ammeter readings gradually increased from the first to the fourth series. This was probably due to the gradual dulling of the cutter.

In plotting the curves, the test readings were first corrected: The power readings by means of the efficiency chart of the motor; the amount of metal for loss of speed of the machine. The curve as plotted is the curve of the average value of powers. Where the curve shows an amount of metal removed of say 5½ cubic inches per minute, this amount may be due to a depth of cut of 1/16 inch and a feed of 16 inches or to depth of cut of ⅛ inch, and a feed of 8 inches, or perhaps a depth of cut of ¼ inch and a feed of 4 inches.

The amount of power required to remove a given amount of metal varied with the speed, depth of cut and feed per minute, and seems to have a tendency to the minimum when the section of the chip removed per tooth approaches most nearly a perfect square. Figs. 1, 2, 3, 4, 5 and 6 show curves giving relation between power required and metal removed under different conditions of speed, feed and depth of cut. They are partly derived from the tests described,

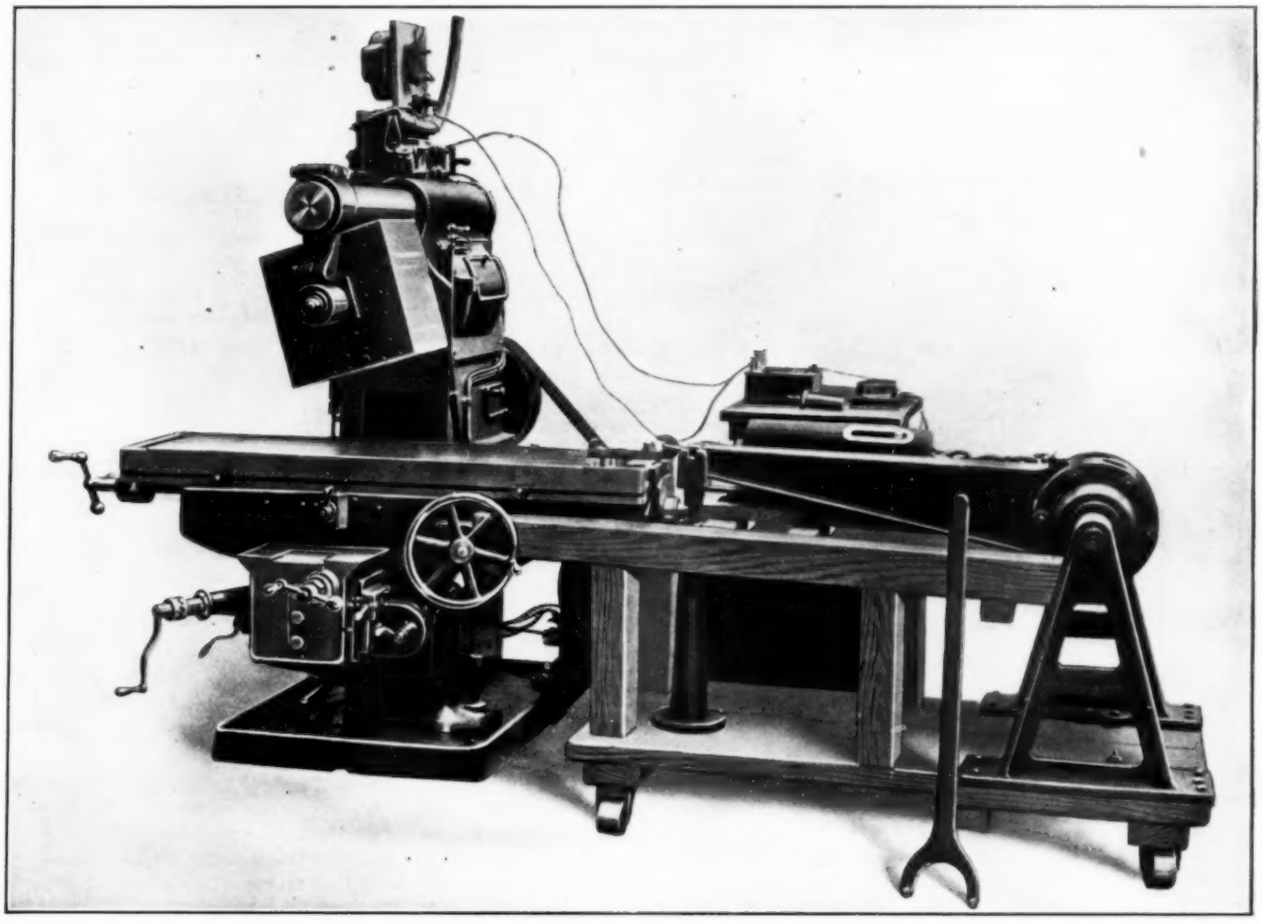


FIG. 7. APPARATUS FOR TESTING FEED EFFICIENCY OF MILLING MACHINES

and partly from tests made for the special purpose of ascertaining these relations. The fact that the power required changes with these conditions of feed, speed and depth of cut made it impossible to plot a single curve giving relation between power and metal removed. Again, the amount of slippage or slowing down of the machine was not always the same for the same amount of metal removed. For this reason the averages have been plotted. The curves were extended to the zero point, but the high point of all curves is the actual highest average obtained, so that in a certain sense the curves also show the comparison of the greatest possible capacity of the machines. This should be taken as significant, however, only when remembering the conditions under which the machines were tested, and then only as a measure for the maximum driving power.

Power Required for Feed Mechanism

Tests made by the Cincinnati Milling Machine Company, as well as by other concerns engaged in the manufacture of milling machines, had shown that a considerable amount of power is required for the feed drive of a column-and-knee type of machine. It was found that as much as 40 per cent. of the total power applied might have to be used for the feed alone: and that this could amount to as much as 3½ horsepower on a No. 4 machine. Inasmuch as I did not conduct any of these tests and do not know all of the conditions under which they were made, I do not feel that I can present the results. The main result, however, as far as I was concerned, was the fact that they made me give very careful consideration to the feed mechanism. If 3½ horsepower is used for the feed, and if that feed is 20 inches per minute (the highest feed found on a modern milling machine) then the pressure against the cutter must be

$$\frac{3\frac{1}{2} \times 33{,}000 \times 12}{20} = 69{,}300 \textit{ pounds.}$$

if there are no losses in transmission. Further, it is not likely that the greatest amount of horsepower is required for the feed at its maximum number of inches per minute. It is more probable that the maximum feed power is used for 10 inches feed or less per minute, in which case the pressure would be in the neighborhood of 140,000 pounds.

A machine using 6 horsepower net for the drive alone (that is, using 6 horsepower at the cutter) would require about 8 horsepower at the pulley for the drive alone, and therefore a total of 11½ horsepower for drive and feed under conditions of feed mentioned above. This is quite a respectable amount for a No. 4 machine. Assuming the cutting speed to be 40 feet, the pressure at the circumference of the cutter must be

$$\frac{6 \times 33{,}000}{40} = 4950 \textit{ pounds,}$$

and this must also be the approximate pressure against the table screw instead of 140,000 pounds. Of course, all these figures are assumed, but they illustrate the computations which led up to the second line of experiments to be described here.

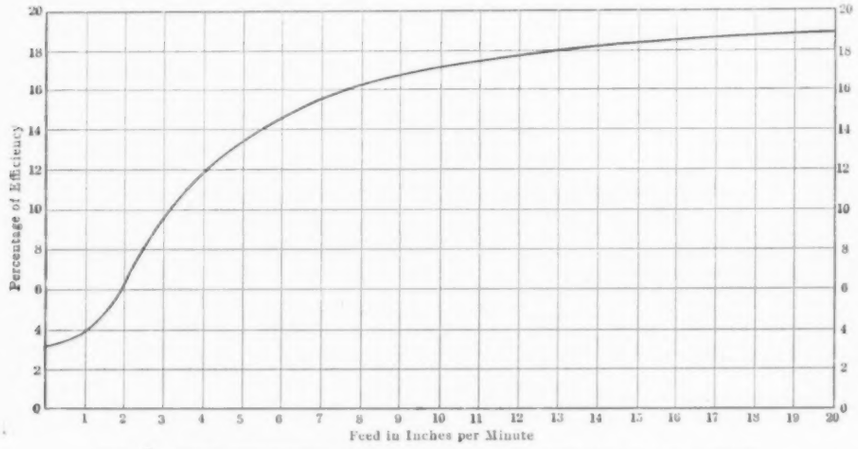


FIG. 8. FEED EFFICIENCY CURVE OF NO. 4 CINCINNATI PLAIN MILLER

In order to determine the efficiency of the feed mechanism, the amount of power used was measured, as well as the amount of work done by the table. As the amount of power required varied widely, and it would be impossible, therefore, to obtain an efficiency chart for some small motor, covering the entire range of powers used, the idea of using an individual motor for the feed alone was abandoned. Instead the same motor was used as had been used for other tests. The efficiency of this motor was not known below one-fourth load. It was then necessary to provide an artificial and constant load for the motor. For this purpose the square box shown in Fig. 7 was mounted on the spindle arbor. It had a paddle inside and a number of obstructions which made the required resistance for the water in the box. By increasing the amount of water in the box, and by giving the paddle various speeds, any load could be produced within the range of the apparatus, and this load was constant. The box was kept from rotating by resting against the overarm of the machine. The dead load was adjusted until it came within the efficiency curve of the motor. The part of the apparatus used for measuring the work done by the table consisted of a dynamometer, graduated and calibrated up to 8000 pounds.

One end of this dynamometer was attached to the table of the milling machine. A chain at the other end of the instrument was wrapped around a drum which was mounted on a brake of the Weston type. An arm, mounted on the brake casing and visible in the drawing had at one time been used to determine the efficiency of the driving mechanism but was not used in this experiment, except to form an abutment for the brake. The brake itself was used only as a safety device, being set at sufficient pressure for the test, but not enough to wreck the machine. It had been intended originally to set the brake for a certain pressure and to have the table feed under this pressure for some length of time, but it was found that the brake was too jerky in its action. The mode of working was, therefore, changed and the test was carried out as follows: All even feeds were taken, beginning with the second lowest and going up to the highest. For each feed the following pressures were selected: 1000, 2000, 3000, 4500 and 6000 pounds. The entire series was repeated once if nothing happened to spoil the test. If something happened to disturb the proceedings, or if something had to be readjusted, then the entire result of the test was dropped and no curve was plotted until two complete series of tests were made without interruption. A sensitive ammeter reading 1/10 amperes was used. The tachometer served again to take the speed of the first driving shaft, and all corrections were made as in the test previously described. With a given feed, an entire series of pressures was gone through, after which the amount of feed was changed for the new series, etc.

Before taking a series of readings, the feed mechanism was disconnected to get the reading of the dead load. Another reading of the dead load was taken after each series of readings was completed: that is, after all the different pressures had been used for one single feed. One observer took the readings of the tachometer; another of the ammeter; a third one of the dynamometer, and a fourth one was stationed at the feed starting lever. The observer of the dynamometer watched his instrument until the pointer reached the proper figure, when he would call out sharply. At this moment all readings were taken and the feed disconnected. Several preliminary tests were made to see if the readings could be duplicated in this fashion, and it was found to be very easy to do so. The rise in the ammeter readings was gradual, and allowed the observer to take the correct reading every

time within a tenth of an ampere. If there was any drop in the speed of the machine, this drop was also very gradual, permitting the tachometer readings to be easily duplicated. The only point not so easily duplicated was the reading of the dynamometer, especially at the faster feeds. If often happened that the feed pressure would go somewhat beyond the pressure intended, but the dynamometer did not change its position when the feed was thrown out, so that the observer could take his reading at leisure, the only difference being that instead of having to plot for, say, 2000 pounds the curve might have to take care of 2100 pounds.

feed efficiency is 10 per cent., then 0.3 horsepower is actually used for this feed. If 10 horsepower is used for the entire machine—that is, for feed and drive—then 7 horsepower is left for the spindle drive alone, and, therefore, the amount used for feed is 3/7 of the amount used for the spindle drive. With a machine having a feed efficiency of 20 per cent. or twice as much, the amount of power used for the feed will be 3/14 of the amount of power used for the spindle drive alone, or 3/17 of the total amount used for the machine. If this amount is 10 horsepower again, then the amount used for the feed will be 1.76 horsepower as against 3 horsepower

Tests upon Efficiency of Driving Mechanism

The third series of tests relates to the efficiency of milling machines as power-transmitting devices: that is, the ratio of input and output of power. Some preliminary tests were made by observing the power at the spindle by means of an absorption brake of the Weston type; in fact, the same brake as illustrated in Fig. 7. This gave fairly good results at the higher speeds, the torque being small; but at the lower speeds and with greater torque the action of the brake became jerky and it was practically impossible to obtain reliable readings. For this reason

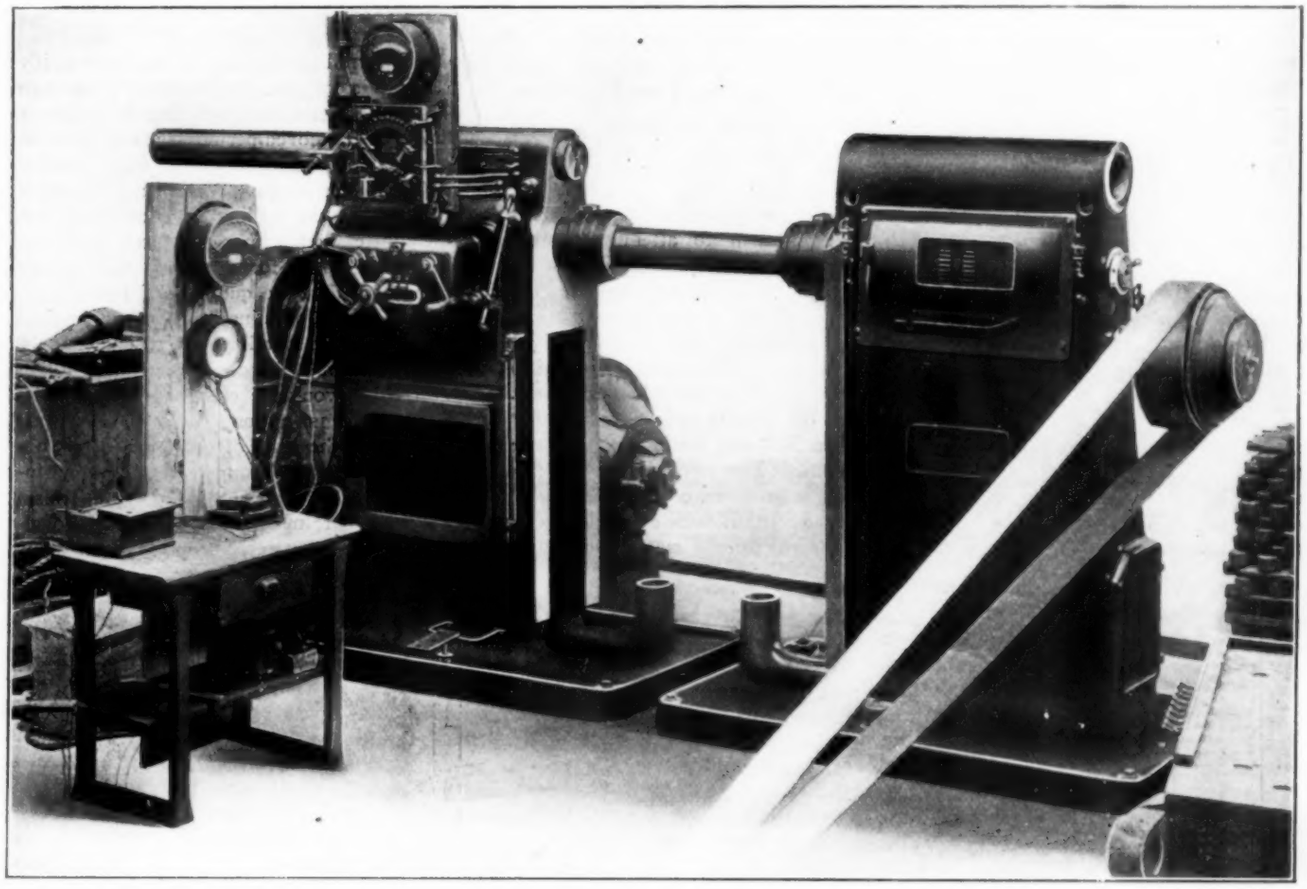


FIG. 9. APPARATUS FOR TESTING EFFICIENCY OF MILLING-MACHINE DRIVE

Fig. 8 shows the curve of average values plotted from these readings of the test on a No. 4 plain miller; each ordinate is the average of the ordinates corresponding to a certain amount of feed.

The importance of a high efficiency in the feed gearing cannot be over-estimated. It may seem that 20 per cent. efficiency is still so low that it makes little difference whether it is this amount or something else. It may seem at a first glance that it is of little importance to the user whether 80 per cent. or 90 per cent. of the feed power is lost in transmission. But a more careful look at this problem shows the importance of high efficiency very clearly. If 3 horsepower out of 10 are used for feed on a machine of which the in the first machine; and the amount left for spindle drive will be 8.24 as against 7 horsepower in the first machine, giving an increased spindle power of 18 per cent. available for cutting. Of the 3 horsepower used by the first machine for the feed alone, 0.3 horsepower is usefully employed while the remaining 2.7 horsepower are employed to wear down the feed mechanism and destroy the machine. Of the 1.76 horsepower used for feed in the second machine, 20 per cent. or 0.352 horsepower is usefully employed, whereas the remainder or 1.41 horsepower is used destructively. It will be seen, therefore, that the power used to break down the machine is almost twice as great in the first machine as it is in the second.

the tests were carried on with the apparatus shown in Fig. 9.

This consisted of two machines of the same type, make and size—namely, Cincinnati No. 4 high power miller—placed opposite each other and connected by a stout shaft. The feed works were removed, as were also knee, saddle and table, so that nothing was left but the bare frames and driving works. The machines were placed with the spindles approximately in line. A flange was screwed to the nose of each spindle; each flange was provided with a tongue engaging the groove in the similar flange opposing it, and keyed to the stout connecting shaft. There was plenty of clearance between tongue and groove and also endwise so

that the connection could behave as a universal joint shaft in case the spindles were not exactly in line. It must be remarked here that the motion in this universal joint shaft was exceedingly small. Flat pieces of steel bolted to the first-mentioned flange prevented the connection from coming apart. One of the machines was driven by a motor while the other drove a generator. The current thus generated was dissipated in a water rheostat, by means of which the amount of current could be closely regulated. There was a set of electric instruments for motor and generator each, so that all readings could be taken simultaneously. Both machines were driven by belts. A tachometer was used to determine if one of the belts slipped excessively. If the generator voltmeter showed considerable drop and the tachometer showed about the proper speed at the first driving shaft of the first machine (motor machine) then the belt to the generator must have slipped. If, however, the tachometer showed a drop, then the belt from the motor to the first machine must have slipped.

The speed-controlling levers of both machines were always in corresponding positions—that is, both were set for the same speed, so that at whatever speed the spindle was running, both driving pulleys were always running at the same speed, and that is the speed at which they are supposed to run under working conditions. Different sets of readings were taken. In one set the current consumed was kept at as near 125 amperes as possible. In another set this amount was 100 amperes; in still another, 80, and in the fourth, 70. Each set of tests was carried out over a number of speeds, namely, the lowest, third, fifth, etc., up to the highest but one. After correcting the motor reading for motor efficiency and generator reading for generator efficiency, the quotient of the corrected readings gives the product of the efficiencies of the two machines.

It would be proper to consider the two machines as of equal efficiency if the conditions of load were the same, for these tests did not attempt to establish the efficiency of an individual machine but of a type of machines and this could best have been done by submitting a great number of these machines to individual efficiency tests and taking the average of the results. It is, therefore, plain that a better result will be obtained by considering at once the two machines as having the same efficiency than to attempt to determine their individual characteristics. It was said that it would be proper to do so if the conditions of load were the same for both machines, but this did not seem to be the case. The load was the same only at the spindle noses. From there on and up to the driving pulley the load increased in the first and diminished in the second machine. The efficiency of the first machine is made up of the efficiencies of its bearings, shafts, sets of mating gears, etc. These efficiencies may be called $e1$, $e2$, $e3$, etc. The total efficiency of the first machine being E, then $E = e1 \times e2 \times e3$, etc. Similarly, taking F as the symbol of the efficiency of the second machine, then $F = f1 \times f2 \times f3$, etc. The f's may be assumed to differ from the e's on account of the difference in load.

It was found, however, on taking the readings that there was such a small difference in efficiency whatever the load, that it seems to be allowable to consider the efficiency as practically constant: in which case the efficiency of each machine equals the square root of output divided by input. The curves presented in Fig. 10 are based on this assumption. It will be seen that the efficiency of the machine varies from 67 up to 79.7. Various tests made at other times have shown repeatedly efficiencies above those plotted in the curves, but it was not thought advisable to embody them in these curves as there were not enough readings to make a complete set and the use of these isolated readings would have a tendency to disturb the effect of the systematic tests.

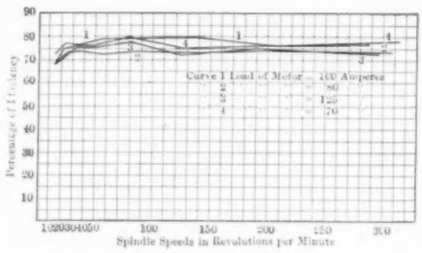


FIG. 10. EFFICIENCY CURVES OF NO. 4 CINCINNATI HIGH-POWER MILLER

Efficiency of Cutters of Different Types

The milling machine is not essentially less efficient as a power transmitter than any other machine tool, but the amount of metal removed per horsepower per minute is low; much lower in fact than for the lathe or planer. Were it not for other properties the milling machine could not compete with either of these two machines. It is fortunate for the milling machine that the question of power consumption is of minor importance in considering the purchase of machine tools. Still it cannot be denied that the milling machine would be esteemed higher if its power consumption could be brought down to the level of the lathe. It is obvious that this cannot be done by increasing the efficiency of the mechanism as the margin is not large enough to allow of any material improvement. Any substantial increase of efficiency must, therefore, be found in improvements of the cutting tool. With this consideration in mind, some tests were made as to the power required to remove a given amount of metal with different styles of cutters. These tests have not been carried out over a long enough period or with a large enough variety of cutters to give absolutely reliable results, yet, incomplete as

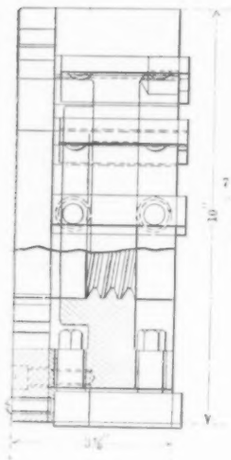


FIG. 11. 10-INCH, 16-BLADE CUTTER

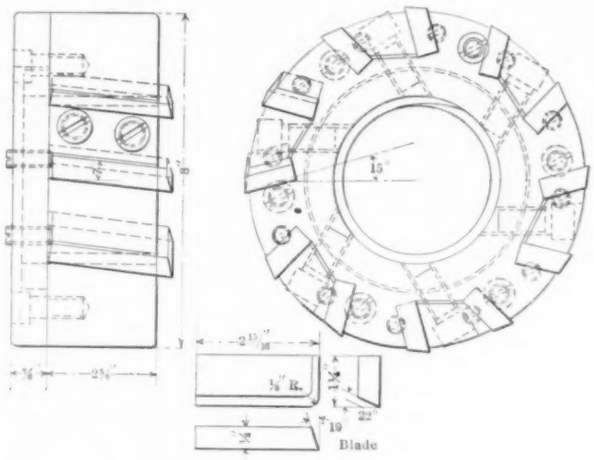


FIG. 12. 8-INCH, INSERTED-TOOTHED CUTTER

they were, they bring out in a startling way the amount of improvement that may be made in this direction.

Cuts made with a spiral cutter with nicked teeth showed a best efficiency of 0.48 cubic inch of metal per net horsepower per minute, and this efficiency was obtained only in a few isolated cuts and with a very sharp cutter. Cuts made with a 14-inch face cutter with inserted teeth and on a No. 4 Cincinnati high-power miller showed a production of 0.64 cubic inch per net horsepower per minute, an increase of 33⅓ per cent. over the spiral cutter. This result confirms the general belief that a face cutter cuts freer than a spiral cutter. The teeth of this face cutter were radial, as it is customary to make them. Tests made with the cutter shown in Fig. 11 showed an efficiency of 0.96 cubic inch of metal per net horsepower per minute, and a few isolated cuts even higher. This is an improvement of 100 per cent. over the spiral cutter and 50 per cent. over the face cutter with radial teeth. The cutter shown in Fig. 12 showed the same efficiency. Both cutters have the blade set tangent to a circle concentric with the cutter, thus giving them a rake angle of 15 degrees. The clearance was 7 degrees. The points of the cutting blades were rounded to prevent injury by burning or chipping, and this reduced the effective rake near the horizontal tangent to this curve. It was for this reason that the blades were set leaning backward as in Fig. 11. But for this curvature at the point of the blades, the simpler construction of Fig. 12 would be perfectly satisfactory. The leaning back of the blades is rather a refinement than a necessary improvement.

It should be borne in mind that the tests made with these cutters were made on a vertical machine which had the same driving parts as a horizontal machine of the same size, and besides an additional two shafts and four gears, so that it is safe to say that its mechanical efficiency must be less than that of the No. 4 horizontal machine used with the spiral cutter with nicked teeth. The action of the feed on a machine using this cutter may be somewhat different from that on a machine using spiral cutters. Whether there is such a difference and what it amounts to has not been ascertained by tests, and might be a promising field to explore. The fact that, generally speaking, the face cutter with rake removes double the amount of metal with the same amount of power as compared to the spiral mill is significant and places the vertical machine in the front rank for slabbing work wherever it is possible to use this type. Equally significant is the fact that a cutter with rake removes 50 per cent. more metal than a cutter without rake. It may be mentioned here that many of these cutters, especially for so-called rotary planers, are being made and have been made for a great many years with the teeth leaning backward as in Fig. 11 but without rake; the makers and users apparently believing that this leaning constitutes rake.

I regret that the requirements of patent laws do not permit me at the present date to describe a spiral cutter and a face cutter built on different principles, which have been tested as to their efficiency. It may be of some interest, however, to know that a great number of cuts have been taken with these cutters showing removal of 1.14 cubic inches per net horsepower per minute, and with entire absence of chattering of machine and spring of the cutter arbor.

The writer is fully aware of the fact that the tests described above are by no means complete, and he believes that they are only a starting point and that much more should be done in this line before we can say that we have sufficient working knowledge of the efficiency of drives and feeds of milling machines and of milling cutters. The fact that so little has been published on this subject has led him to submit this paper, incomplete as it may be.

Patent Experiences—Two Failures and a Successful Wrench

By Wit Bec

Joe was an expert mechanic, having had the experience which eighteen years' work gives a man; he had begun young as a boy apprentice, went out a journeyman, worked on the floor, at the vise bench, and had risen to the chief position in the air-brake room as his regular work, and in the tool room when time permitted; both positions required skill and careful work. He was fully competent from the mechanical standpoint, a factor which most patentees lack, and which is one of the main causes for so many unsuccessful patents.

Passing forty and getting tired of the whistle and a boss, he hit out for himself, renting a small shop which he filled with the tools and equipment he used to have in his tool room at home, and took in all classes of machine work within the capacity of his shop. Here was a standard make of lathe with electric motor drive, fitted with gear-cutting and milling attachment, hand forge, emery wheels, milling cutters, and tools by the bushel; the very equipment needed by a man who had to do any and all kinds of work. Each tool was purchased to meet a need for it in some model making; either models for others or for himself. An inventor is appealed to by those who are working on an idea, either for help or to make up the models. Joe had five patents already to his credit, beside having worked out as many more original ideas, discarding some, and holding others to perfect and patent.

In the back room of his shop he and I would talk over our patents. Joe had five patents; I had three. He had scored one success: I, none. There is a freemasonry among inventors, the countersign being an original idea embodied in a working model. It passes its maker to what is secretly withheld from others.

Joe and I had eight patent experiences to talk over covering the average happenings to a patentee. To the readers of the American Machinist who have passed through the mill, our experiences will recall some of their own, and to those now on their first patent they may serve as a warning of what is ahead.

I walked into the back room of Joe's shop one afternoon to show a model I was then working on, and glancing at the rack above his lathe noticed a drawing on a piece of paper. "What's this, Joe?" I asked. "Just a sketch of a pump piston I am repairing for the town pump." Of course, after looking at the drawing I turned over the paper as we all idly do, and here was a boldly printed letter head of a huge manufacturing company, with Joe as president, the other officers in turn, and the legend in heavy faced type "Incorporated Under the Laws of the State of . . . . Owners of Patent Right No. . ."

"Since when?" I asked.

"Oh! A while ago our company was promoted with a capital stock of 100,000 shares, of which I own 25,000, and the other four an equal amount between them, with a treasury stock of 50,000 shares."

"Is the sale of treasury stock meeting expenses?"

"Well I should say not. We can't sell a cent of it. Here is a heavily financed corporation for you! Its whole assets consist of two models; one out now on trial, the other on that back shelf there. Not a cent of its stock has been paid for. My enthusiastic friends (?) saw so much profit in the patent right that there was no need of *our* money floating the company, but we should follow the precedent of all high-finance methods and let the other fellow do that. The others come to me for models, traveling expenses and my time to personally show the patent, but they never come through with any cash. When I talk assessments it's like a Lawson exposé of methods—it shakes confidence. My only consolation is that it is entirely composed of members here in town, or otherwise what a skinning I would get!"

Here is one of the most alluring snares of the patent sharp. He will promote a company! Place you as president! He will put your company in touch with the very manufacturers you wish to reach, and through him success will come to your company. You will find yourself skinned both coming and going.

Joe reached up on the shelf for an old, hard and dried piece of horse-shoe chewing plug, sliced off a palm full, carefully pulverized it between thumb and palm,

and lit up with the remark, "Wit, ever tried this? You'll never smoke any other if you do." I lit up out of a tin box, and knowing that when a smoke was on, talk began, put the question, "Joe, you sold one of your patents, didn't you?"

Two Failures

"Yes, I sold my third patent. My first patent was on a safety pop, to be locked when once set, so that the engineer could not change the set of the pop. That was 23 years ago. My rights have expired and parts of my ideas are now being freely used by locomotive builders. My second patent was a power coal loader, and I thought success was surely mine. I pictured every railroad adopting it at each coal yard, and large returns seemed so sure that I spent freely in perfecting an expensive full-sized working model and operated it for a few months to perfect it. Well, I just about went busted. I spent all I could on it, and interested friends went in with me. My whole future was tied up in that one venture. If it succeeded a fortune was mine, if it failed I was badly hurt. Well, it failed. The railroads adopted another method and left me and my hopes high and dry. Wit, a man takes the death of a cherished hope, one that he has thought over, worked over, and placed his all-in-all in, almost like a death in the family. I was hurt, discouraged, and so far set back financially that for the next three to four years I was strictly up against it."

How many of us have followed the idea, always feeling that success is just *barely* out of reach and the next detail perfected will get it, only to come face to face with a mortgage on the home, and lose our former friends, who now think us visionary, impractical, and wish to avoid us. But let us score a success with the next patent, and they always did believe in us. "Quite a genius," they say then. Joe hit it on the next one.

A Quick Sale

"Which patent was it you sold, Joe?" I inquired.

"The off-set wrench. While on the air-brake work in the shops, I had seen the need of a good off-set wrench, and so made up just what I wanted to use, developed it, and took out a patent. Nothing came of it, although I tried hard to get some interest taken in it, both by personally laying it before those around me, and by correspondence, but there was nothing doing. I guess nearly a year passed, when one day a stranger happened in the shop, apparently rubbering through. Things of interest slowly called him over to the air-pipe bench, and casually he took up my wrench, examined it and remarked, 'Pretty fair wrench. Where did you buy it?' 'I made it myself.' 'Patented?' 'Yes.' 'Patent for sale?' 'Yes.' 'How much will you take for it?' 'I will sell it for $2000.' 'I'll take it for that price. You get the papers from home, come up to a notary's office during the noon hour, sign a deed over to me for it, and I will give you a check that the bank will cash today.'

"Wit, I'm not shortening the conversation much. That's about all there was to it. By one o'clock that afternoon I was back at work with a certificate of deposit from the bank for the money. In thinking it over since, I am satisfied he was there on purpose to buy my wrench, but I got my price for it and have no regrets."

That was a pretty quick sale, wasn't it? All talked over and done in less than a half day.

"Joe, how much do you figure you netted on that patent?" I asked of him.

"Well, in the first place, Wit, the wrench was a simple invention and not very costly, unlike my second one, which was a large machine of many parts, and which cost a good deal to make. This patent on the wrench, including all the forgings, machine work that I put in on the different models until I finished the one I got a patent on, my total expenses for materials and so on, and adding in the patent right cost, I don't think exceeded $150 or $200 at the outside; so that I made say, $1800."

Now I call that a successful patent. In fact, I call any patent successful that is sold for more money than it actually cost up to its sale. Some single patents are fortunes in themselves—some exceptionally important ideas bring quite large fortunes—but by far the greater number of patents that are sold bring an average price fairly close to this sale.

The time from starting on the first model to the date of applying for a patent, covered only four months, $1800 for the result of four months of working at odd times! One such sale only is not much, from the standpoint of the general public, but if an inventor realizes from three or four patents such a price, the aggregate begins to count, and should he be fortunate enough to hit a good one in between, selling for over ten thousand dollars, his success begins to attract attention in the press.

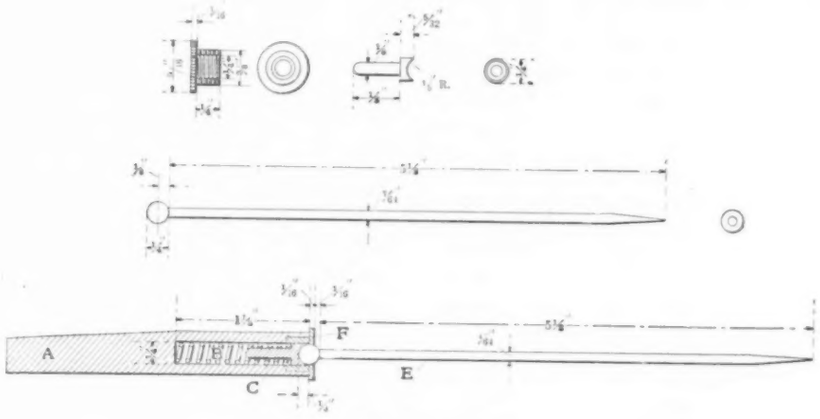
A Center Indicator for the Miller, Drill Press or Boring Mill

By F. J. Deegan

This is a handy little tool to have in one's kit. It consists of a shank *A*, which can either be made to fit the spindle, in which it is intended to use it, or to fit a Morse or other taper sleeve so that it can be used on various machines.

The pointer *E* has a ball on one end of it which works in a socket formed by the nurled nut *F* and the seat *C*, which is forced against the ball by the spring *B*.

The work which has been marked off is clamped to the table and the pointer *E* is thrown over at an angle. When in this position, if the spindle be turned, the end of the pointer will describe a circle, the center of which will be in line with the center of the machine spindle. The work is then adjusted so that the part marked for boring is concentric with the circle described by the pointer, and then secured.



THE CENTER INDICATOR

It is reported that an Austrian inventor has produced a mechanical device which it is claimed will assort metal coins which have been thrown together regardless of their denominations, placing each denomination in a separate basket. The various coins are thrown indiscriminately into a funnel at the top of the machine, and from the funnel they slide downward, alighting on a spiral track. This track has a protecting edge or raised border containing slits corresponding to the various sizes of the coins. As the coins of various denominations glide downward onto the track, through some peculiar mechanism of the machine they pass through the slits corresponding to their various sizes, entering their respective baskets at the bottom of the machine. It is said that several firms handling large amounts of coin daily have tried the machine with satisfactory results.

Practical Letters from Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

WE PAY FOR USEFUL IDEAS

A Method for Making Armature and Stator Core Segments

A difficult question in electrical manufacturing is, what is the most practical way to make core segments from 0.025 inch thick stock for armature and stator cores of electrical machines? Mr. Haff on page 910, Vol. 31, Part 1, wishes to know of a cheaper design of tools, and quicker and more accurate method of production, for such segments than those that are ordinarily in use. I have spent some six years in this line of manufacturing and know the methods that are in general use. Recently I have found a new method for making these core segments of which the following is a brief description:

Fig. 1 shows a core segment for the stator of a 625-kilowatt alternator to run at 3000 revolutions per minute. Fig. 2 shows another core segment for a 5000-kilowatt alternator to run at a speed of 1500 revolutions per minute. Fig. 3 shows a similar segment for a 1500-kilowatt alternator to run at 90 revolutions per minute.

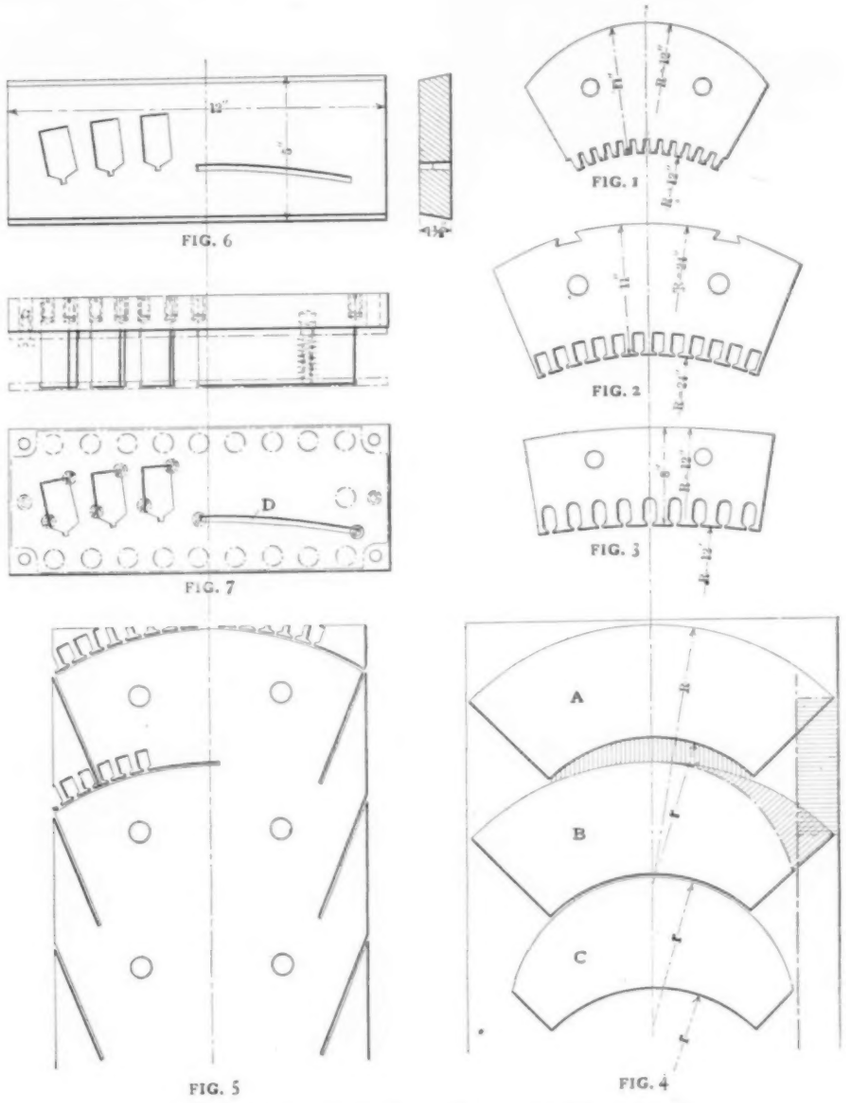


FIG. 6 FIG. 1 FIG. 2 FIG. 7 FIG. 3 FIG. 5 FIG. 4

PRESS TOOLS FOR ARMATURE AND STATOR CORE SEGMENTS

The radii for these segments are quite different. For the segment of Fig. 1 the radius is 12 inches; for Fig. 2, 24 inches and for Fig. 3, 12 feet. The chords of the segments and the center angles are also different, as can be seen from the engraving. In order to apply my method and use a single tool for these different sizes and shapes, it is necessary to change the concentricity of the segment arcs, and to make these arcs of the same radius. This is shown in Figs. 1, 2 and 3, and especially in Fig. 4 where the difference between concentric and eccentric core segment arcs is best shown.

Fig. 4 shows a layout of three-core segments. The segments *A* and *B* are shaped with concentric arcs, and segment *C* with eccentric arcs. With the eccentric design the diagonally hatched part is lost but on the other hand the horizontally and vertically hatched parts are gained, and offset the other loss. Mr. Haff has found from experience that it is impractical to make a compound die for the simultaneous blanking and piercing of core segments. It is much more practical to produce these pieces in two operations. In my method I punch only the radial sides of the segments and the holes in the first operation, and then in the succeeding operation punch the notches and curved sides.

For cutting the radial sides and holes I used two sets of thin shearing blades and dies and two punches and dies for the holes. These are adjustable for the various sizes of core segments. Fig. 5 shows the work of this set of tools. The punch consists of an iron plate 20 inches wide, 40 inches long and 1⅛ inches thick, machined with T-slots running lengthwise. On this plate are fastened, by screws which are adjustable in the T-slots, iron punch holders into which the shearing blades are tightly driven.

The easiest and best way to set these shear blades is to make a pattern stencil of sheet steel that is exactly of the shape and contour of the finished core segment. After having adjusted and fastened the shear blades in position, the dies are set to them. The guide or indexing pin is also properly located in order to register the sheets as they are fed through the press.

After a number of core segments have been blanked out in the first operation, they are taken to the notching press and notched and the curved outlines are sheared to size and shape. The die for this operation is shown in Fig. 6 and the punch in Fig. 7. At *D* is indicated the shear for the curve. The advantages of this method are the saving of material and the cheapening of the tools. At the same time the punching operations do not require as much time as those of the usual

methods and in this way the core segment costs are reduced.

F. M. PITTSBURGH.

Frankfurt, Germany.

Boring Jig for Crank Cases

Jig shown herewith was designed by me to enable the crank cases to be produced in reasonable time and correct. Formerly for horizontal centers we trusted to saddle screw division and for vertical centers, trusted to dropping or raising the boring bar to scale on the machine. The results can be better imagined than described. The jig consists of table *A* bolted onto original table, having feathers *B* to insure the table being square after moving and replacing. Upon this table at each end stand two brackets *C*, fitted with hardened bushes. In the center of the table are four cast-iron locating blocks *D*, each fitted with feathers to fit the center slot and circular steel blocks to fit the crank case.

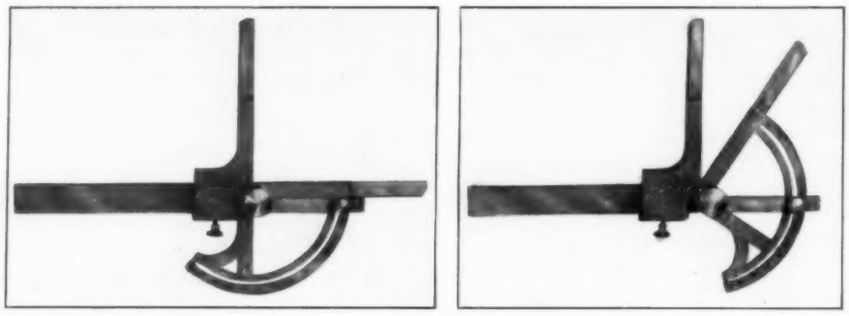
The method of operation is as follows: The cases are milled on the end face and the holes in them which the connecting rods pass through are bored out in a jig on the vertical miller. They are then placed on this boring jig with locating blocks fitting the two center holes, and one block in each end hole, there being six holes in the crank case altogether. The crank case is then held down by ordinary clamps *E*, with a bolt through the clamp, block, and into table. The holes *G H J K L* are then bored through bushes, thus being sure of being correct. *G* is the magneto-bearing hole, *H* the camshaft hole, *J* the crank bearing, *K* the idle-wheel bearing, and *L* the pump bearing. Only *H* and *J* require boring right through the length of the case, therefore, in the back bracket only two bushes are fitted, but for facilitating manufacture of the jig all holes are bored through both brackets. Short bars are used for *G K L*, and long bars for the other holes. The crank case is shown (partly) dotted in thin lines in both top views, and will, I think, give a clear idea of the job and jig.

I think this jig is somewhat novel on account of its simplicity, as by removing the loose blocks and brackets the table can be used for any ordinary job and also other jigs designed to suit various jobs and to fit this base. To make drawing clear I have omitted a plan of the brackets. These can be seen plainly in top views; these are also fitted with steel feathers fitting into the center slot of the large table, which is bolted down to the original boring-machine table by four bolts, shown in the plan.

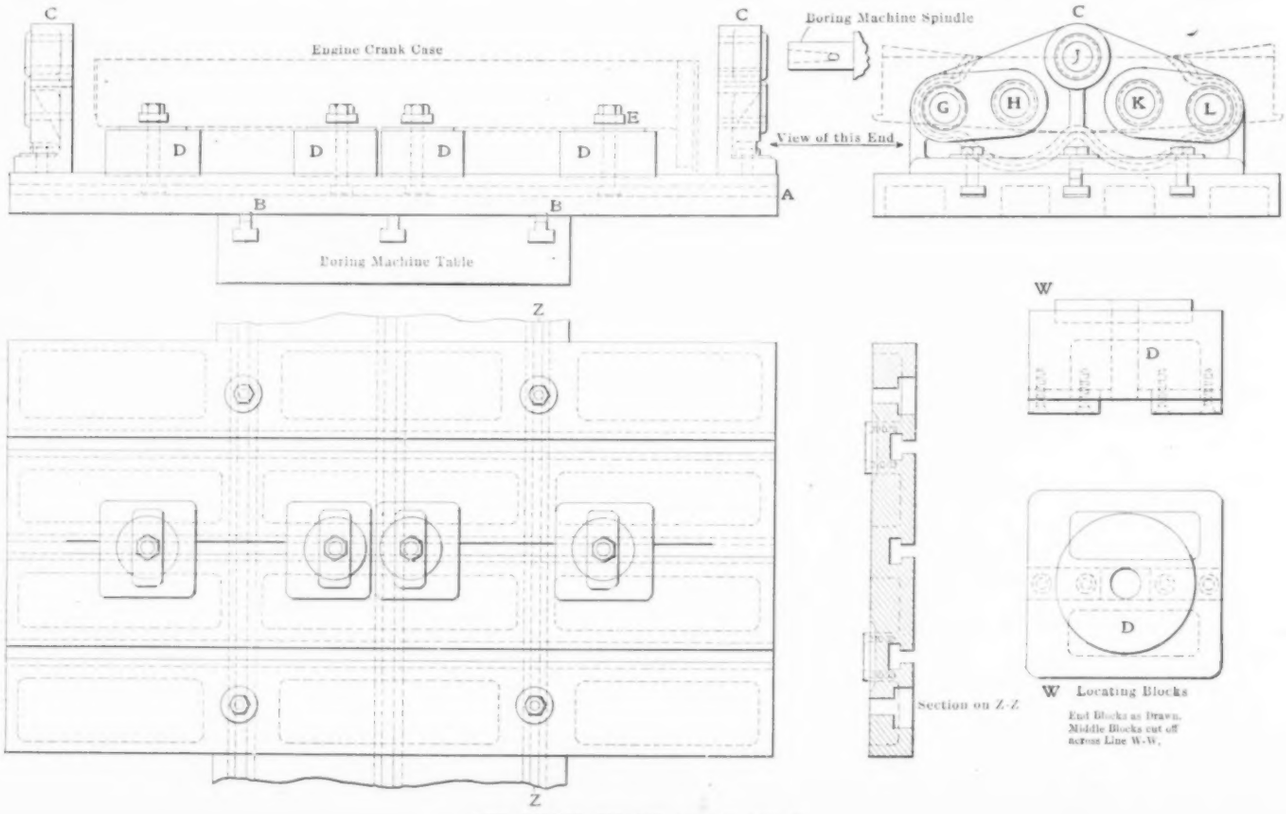
Birmingham, England. T. A. J.

A Handy Combination Tool

I send herewith two photographs of a combination tool I bought along with a lot of other things recently. It has evidently been made by a good mechanic for his own use; let us hope it was not made on the boss' time, for if it was it probably cost the shop quite a lot. It can be used as a caliper square, a taper gage, a protractor and a try square. When used as a taper gage it will, owing to the shape of the upright jaw, gage tapers which run down to a sharp point. That is to say the two jaws can be so



A COMBINATION TOOL



THE BORING JIG FOR CRANK CASES

adjusted that they touch at the bottom near the beam. The beam is graduated and is a snug fit for the sliding jaw. The sliding jaw is hardened and lapped square with the beam. The swinging jaw is also hardened and lapped flat on the edge which touches the upright jaw when adjusting it to set it as a caliper square. The ends of both jaws are lapped to a circle on the outsides so that the tool can be used for inside measurements. The arc is nicely divided and the range of movement is 130 degrees. The swinging jaw can be swung so that it is at right angles to the sliding jaw. Setting for angles is accomplished by the graduations on the arc and a line on the beam extension. A nurled set screw secures the arc and swinging jaw and another set screw secures the sliding jaw.

WM. B. MASON.

Philadelphia, Penn.

Turning Tool for the Automatic Screw Machine

The screw, shown at *A*, Fig. 1, is an ordinary hexagon-head affair produced

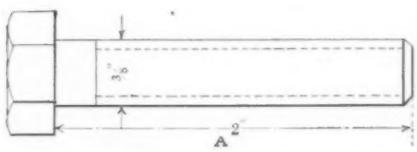


FIG. 1. SCREW-MACHINE WORK

by means of some interesting tools on the Simplex multiple-spindle automatic screw machine.

The tool in first position instead of the usual single-cutter box tool with back rest is made to carry three cutters, which stand at unequal hights. The highest is set farthest from the center so as to step down a little below the flats on the hexagon stock. The second highest roughs down the next step and the third turns a shade over size so that the piece when ready to index from first to second position appears as at *B*, Fig. 1.

This three-tool mill, Fig. 2, deserves special notice. It is really an adjustable hollow mill with all of the good and none of the bad qualities of the latter. Most screw-machine operators are aware of the trouble it is to get a hollow mill to cut equally on all three edges, and to size. With this mill, the tools standing at unequal hights, one is always sure of each tool doing its work and also on account of the narrow width of cut one can feed nearly three times as fast.

The tool, Fig. 3, for second position is for shaving and rounding up the end of the screw. By using rollers one can burnish the stem by setting them a shade hard against the work. Now in the shaving operation the finishing tool has con-

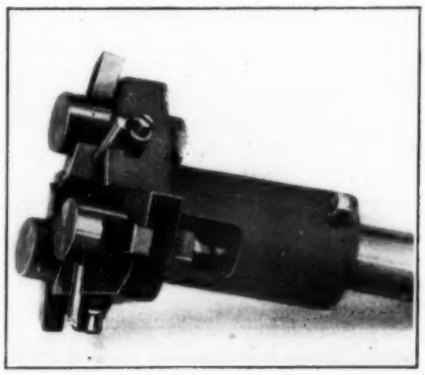


FIG. 2. ROUGHING TOOL WITH THREE CENTERS

siderable to remove as it reaches the screw head where the steps have been left by the three-tool mill. Here is where the adjustable feed cam on the Simplex machine shows up to advantage.

This cam is a simple disk rounded and polished on each side. To make a long piece it is set at a wide angle and *vice versa* for a shorter piece. By using this cam the feed as it nears the end of the

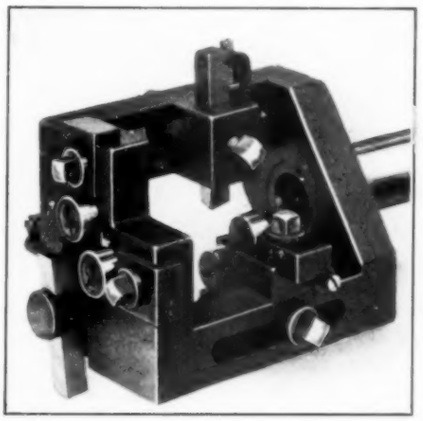


FIG. 3. FINISHING BOX TOOL WITH ROLLER BACK RESTS

travel is gradually retarded and so by the time the finishing tool is up to the bolt head the chip is very light and a nicely shaved screw is the result.

While the shaving tool is working, a tool in the second cross-slide chamfers the head of the screw leaving it ready for threading. The threading operation is accomplished with the die running on and off while the other tools are working.

Cologne, Germany. C. M.

A Hardening Kink

The wheels in an automobile change-speed gear box are required to be as light as is consistent with strength. This is so that the clutch shaft will come to rest quickly when disengaged from the fly-wheel.

The firm with whom I was connected some years ago had in their gear box a wheel similar to the one shown in Fig. 1. This gear was to be carbonized on the teeth and hardened. A batch of 50 were required. The first method tried was to machine them to finished size (plus grinding allowance, of course) and fill in the recess at *B* with fireclay, then bury them in a cast-iron box full of bone dust. This was subjected to a low heat over an extended period in the usual manner. After reheating to a good red heat the gears were then quenched, and it was discovered that most of them had cracked at the junction of the web and rim, and the remainder were very badly warped.

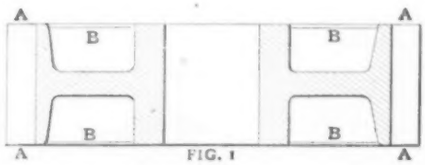


FIG. 1

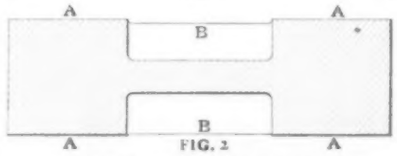


FIG. 2

PIECES TO BE CARBONIZED

To overcome this I suggested the following method, which proved to be very satisfactory: The blank was turned to the lines *A* and carbonized in bone dust as before, but without quenching; when cool it was turned at dotted lines *B* to the depth of the carbonizing; the blank was then reheated and quenched. This had the effect of hardening the teeth and bore faces and leaving those at *B* soft. The gears can then be machined out at *B* to correspond with the section shown. Similar treatment to this is also applicable in case-hardening pieces such as that shown in Fig. 2. This is lettered as in Fig. 1, so that the same description applies.

Glasgow, Scotland. J. H. JOHNS.

In 1901 there existed in Germany 12 automobile factories employing 1589 persons, while in 1906 this number had increased to 34 factories with 10,347 employees. In 1901, $431,873 in wages were paid by the factories, or $272 per workman, while in 1906, $3,171,012 were paid for wages, or $307 per workman. The total value of production shows nearly a tenfold increase in the five years. It amounted in 1906 to $12,200,000.

Discussion of the Previous Question

Letters from Our Readers Showing How Many Men of Many Minds Look upon Various Subjects Opened up in Previous Numbers

WE PAY FOR THESE ALSO

The Working Foreman

One of the first men who ever gave me any advice in a business way told me that if I ever had more than three men working for me to just stand round and watch them and not try to do any work myself. I believe he had been building a house at the time, which may account in a measure for the low limit he set. I was reminded of this conversation by Mr. Coan's article on page 990. What the limiting number of men who can be handled by a foreman who is also working should be, is certainly variable and will depend on the foremen, on the men and on the job. A foreman's duties are threefold, first to lay out and divide up the work to be done, second to show men how to do it, and third to do police duty by seeing that they do it. To this many times is added that of inspector, to see that they do it well enough.

As for the first—the work in some shops can be laid out in a few minutes so that it will take care of itself a week. In job shops and on special work it requires the best part of a foreman's time to keep his work planned so that the men have jobs best adapted to them.

The second, showing the men what to do, does not merely mean showing men who are not competent but also showing them how their work fits into the completed machine, so that they may know where they must be careful and where they can "let it go." If it takes much time to lay out work it is apt to take much to show the men, and *vice versa*.

The last item is the one that ought to be the least important, but, sad to say, oftentimes costs the most. Police duty is offensive to the watcher and the watched and this is what usually limits the scope of a working foreman. During the past few months it has been the fate of many shops to cut their forces down to those few standbys who are liked because they like the work well enough so that they don't have to be watched to keep them up to it. Shop forces have dwindled to the point where many foremen have preferred to do some work at lathe or bench rather than stand around idly watching men who do not need it.

When things begin to pick up again we are going to hear a good deal about the degeneration of the machine trades, just because the shops will have to hire back these fellows that have to be watched.

The worst objection that I ever found to being a working foreman was that it ties one too closely to one spot in the shop. If a foreman has nothing to do but travel up and down the room, then the men take it as a matter of course that he should glance at their work whenever he is around their way, but if he is working at a lathe and wants to see what is going on he must take a special trip, and then all hands know that it is just a police patrol and resent it accordingly.

The best discipline makes the least show of authority. It is enforced by the moral influence of its own presence without display of the big stick. A man who will soldier with the boss at his elbow is a subject for the grand bounce and nothing else will cure him.

Fitchburg, Mass. ENTROPY.

A Cheap, Efficient, Adjustable Section Liner

I have, from time to time, seen in the AMERICAN MACHINIST good, bad and indifferent section liners.

There is an old saying that "a good drawing is spoiled by poor lettering and a poor drawing is improved by neat lettering." I should say that it all depended on the degree of goodness or badness in both cases—but I do know that a good outline will look very badly if the section lining and shading are poor.

In 1873 I was laboriously crosshatching some work with two triangles one inside the other—holding one and moving the

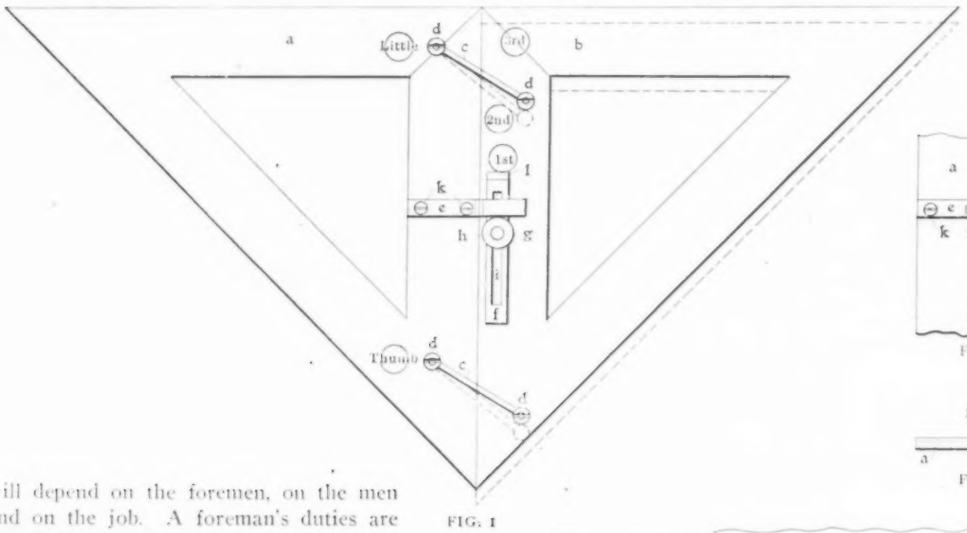


FIG. 1

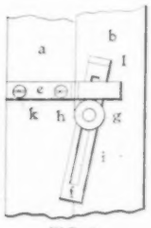


FIG. 2

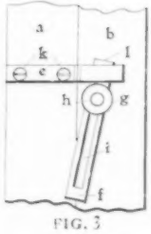


FIG. 3

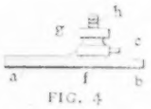


FIG. 4

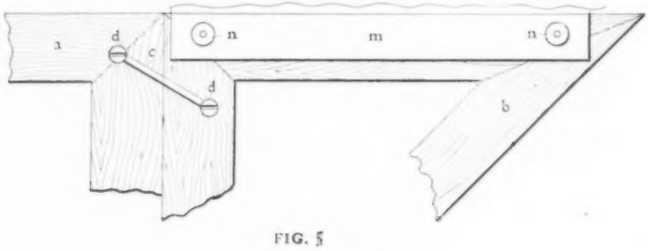


FIG. 5

AN ADJUSTABLE SECTION LINER

other—when the idea struck me which I present herewith.

There are section liners for sale, some cheap, others expensive, but when one comes to a thumb tack in his operations they fail to glide over it and pursue the even tenor of their way. Figs. 1 to 5 show how to make a liner that is cheap and will not only glide over thumb tacks but will enable its operator to perform stunts that none of the others will permit. Two wooden triangles at 25 cents each, a few screws and the other parts which are simple to make; when through using it, fold it and hang it up.

Fig. 1. This section liner consists of two 90x45-degree wooden triangles *a* and *b* held in contact by two india-rubber bands *c c* as a center; it will be seen that the slightest movement of *f* in this manner will make the spaces between the lines slightly less. Fig. 4 shows a rear view showing the shape of *e* more clearly—this allows either *a* or *b* to be tilted upward in passing over a thumb tack or any small obstruction.

Fig. 5 shows an attachment for ruling irregular or wavy tints, *m* is a piece of printer's lead or cardboard, its outer edge being cut in an irregular or wavy line. It is fastened to the triangle *b* by the thumb tacks *n n*.

The operation of the liner is as follows: I place the first three fingers of the left hand on *b*, the little finger and thumb resting on *a* at or near the points indicated and lettered. Holding *a* down firmly, *b* is slipped over the round-headed wood screws *d d*. Projecting from *a* is the metal arm *e* fastened to *a* by two small flat-head wood screws *k k*. The vertical screw *h* is fixed at its lower end to the triangle *b* by a small pin or other suitable device to prevent its rotating and upon this is operated the nurled clamping nut *g*. The movable regulator *f* having the slot *i*, through which the screw *h* passes, is bent up vertically at *l*, a distance equal to the thickness of the circular base of the clamp nut *g*. It will be seen that the space regulator *f* is capable of being moved forward or backward as desired and can then be rigidly fastened to *b* by the clamp nut *g*. In Fig. 1, it will be seen that the distance through which *a* or *b* can travel is limited to the distance between the forward edge of *e* and the rearward face of *l*, and the forward face of *g* and the rearward edge of *e* as shown by the dotted lines. Figs. 2 and 3 show *f* moved sidewise with *h* moved toward the operator as far as the spacing regulator *f* will permit; then holding *b* down firmly and lifting the thumb and little finger from *a*, the tension of the rubber bands *c c* will draw *a* down to its limit, the operation being continued *ad lib*.

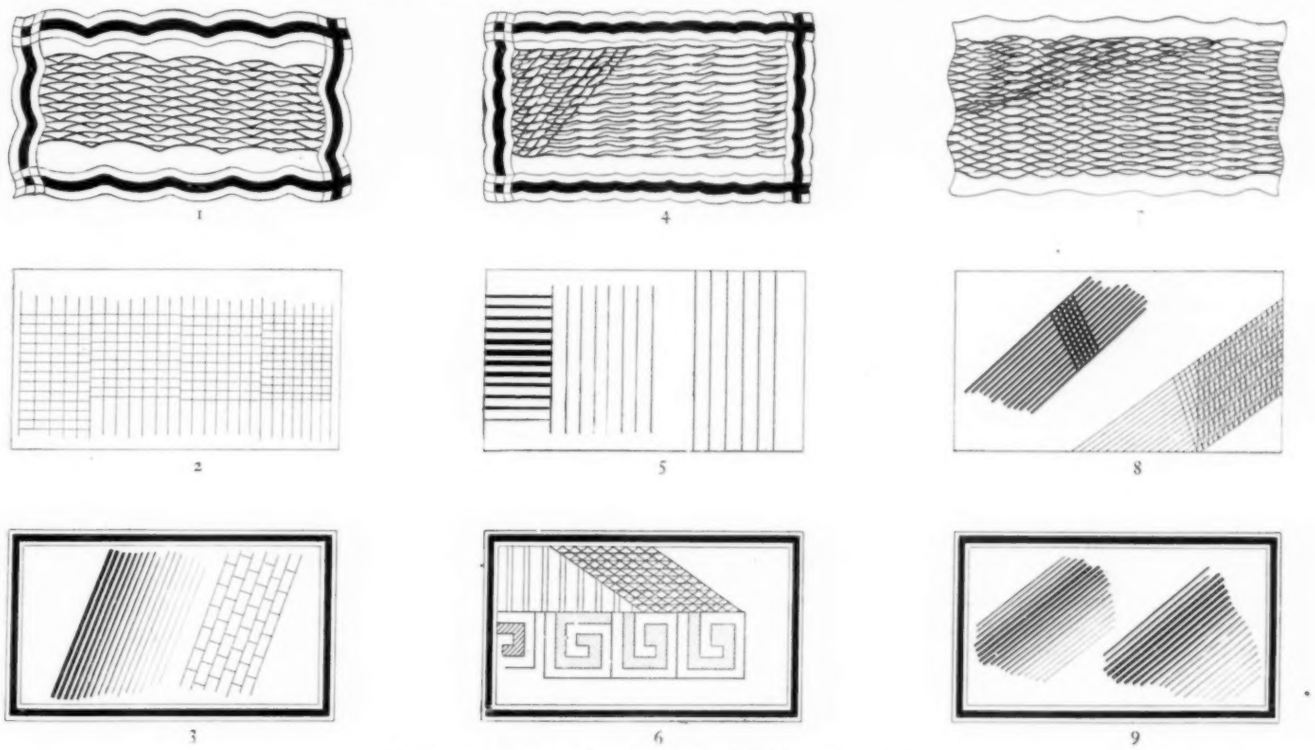


FIG. 6. SAMPLES OF REGULAR AND IRREGULAR LINING

True or eccentric Greek borders, plain and fancy corners for borders etc., are rapidly laid out. An irregular tint made as shown in the accompanying samples cannot be reproduced even by the operator himself. If printed in blue on a buff bank check, it is almost impossible to reproduce or alter what is written upon it in ink. Samples 1, 4 and 7 (Fig. 6), are specimens of irregular ruling or tints; 2 is a sample of the micrometer adjustment as shown in Figs. 2 and 3; 3 is a border of plain shading and brickwork; 5 shows for itself; 6 shows some cross-hatching and parts of false Greek borders; 8 and 9 show cross-hatching and shading, the effect in the dark part being obtained by thickening the lines, not altering the spacing.

Chattanooga, Tenn. J. P. SUVERKROP.

The Band Saw as a Machine Tool

On page 543 I noticed an account of a band saw in the machine shop. In shops building textile machinery they are used quite extensively for cutting sheet-steel plate up to ⅛ inch thick. The saw used is about the same as described, but it is supported by grooved rollers above and below the table, which makes the saw very rigid in action. These rollers are grooved a few thousandths wider than the saw is thick and the depth is such that the bottoms of the teeth just clear the outside of the roll.

PAUL W. ABBOTT.

Wilkes-Barre, Penn.

Lubricants and Advertisements

I have used every kind of lubricant for drilling, milling, planing and screw cutting, but for tools in general I get best results from lard or animal or fish oils. Where a heavy flow of lubricant is necessary as for clearing the chips, particularly for heavy cuts, I always use soft soap and water, and have found good results with a good many compounds sold in the open market for that purpose. I agree that any tool will keep its cutting edge much longer with lard or animal oils.

Any combination of cutting oils with cotton-seed oil in it is bad. While they may cut freely they gum so badly that the slides of the machine get frozen and have to be thoroughly cleaned.

I am interested in all the AMERICAN MACHINIST contains from the front page to its back, and I do not miss any part, and we can get very instructive ideas from the advertisements. There is not an issue in which I do not find something containing good information in the advertisements.

Louisville, Ky. HERMAN FLETCHER.

Dividing on an Engine Lathe

The article, "Dividing on an Engine Lathe," at page 491, reminds me of a scheme I once used for a similar purpose.

It was necessary to make a graduated collar to give a micrometer reading for a certain machine. The thread was eight per inch, so the collar required 125 graduation marks. As the shop equipment was far from the best, it was up to me to do it any old way as long as I got it done.

Accordingly I put the large face plate on the lathe, and with a sharp-pointed tool scratched a fine line around its circumference. I then made a light prick-punch mark on this line, and with a large pair of dividers stepped it off into five equal spaces, prick-punching each step after I got the proper distance. Then with a smaller pair of dividers I subdivided each of these spaces into five equal parts and again subdivided each of these parts into five.

This divided the face plate into 125 equal spaces which were approximately right, as I had avoided the accumulated error. I then made a chalk mark near every fifth prick-punch mark and was ready to graduate the collar. The mandrel holding the collar I placed on centers and drove a wooden wedge behind the tail of the dog. I put a sharp-pointed tool in the tool post and set my surface gage about the hight of my centers. Then drawing the face plate around until the needle of the surface gave coincided with every fifth mark (the chalk-marked ones), I drew the long lines on the collar with the pointed tool.

In going around the second time I stopped at each mark and drew the short lines on the collar. The job was perfectly satisfactory, for owing to the great difference between the diameter of the face plate and the collar the error was not appreciable, and the job did not take nearly as long as I supposed it would when I started it.

Belleville, Ont. C. E. M.

A Graphic Solution of an Exponential Equation

A year or more ago, in connection with some work on graphic computations at the Sheffield Scientific School, we made a graphic solution which is of interest in connection with Professor Peddle's valuable articles which have appeared recently in the AMERICAN MACHINIST. The method of obtaining the solution was simple and may be of use to others in solving

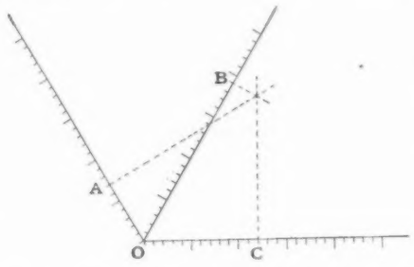


FIG. 1. TWO MEETING LINES AND BISECTOR OF ANGLE BETWEEN THEM ARRANGED TO EXPRESS ADDITION

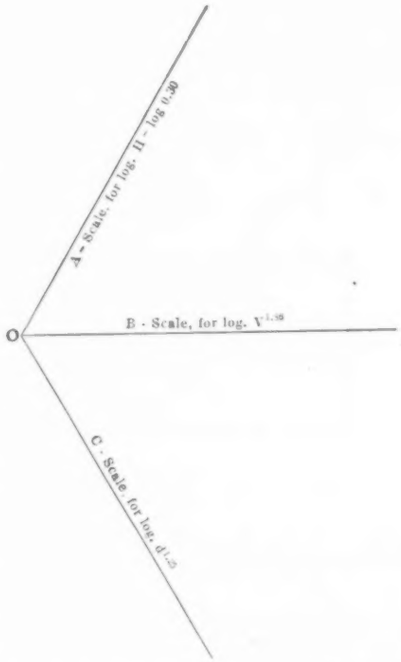


FIG. 2. ARRANGEMENT OF THE MEMBERS OF THE EQUATION ON THE AXIS

similar equations involving fractional powers.

The formula was an empirical one for the flow of water in clean cast-iron pipes as follows:

$$(1) \qquad H = 0.38 \ \frac{V^{1.86}}{d^{1.25}},$$

where

H = The head in feet per 1000 feet of pipe,

V = The mean velocity in feet per second, and

d = The diameter of the pipe in feet.

Taking the equation in its logarithmic form,

$$log.\ H = log.\ 0.38 + log.\ V^{1.86} - log.\ d^{1.25},$$

or, bringing down the exponents,

$$log.\ H = log.\ 0.38 + 1.86\ log.\ V - 1.25\ log.\ d$$

Transposing,

$$(2) \qquad log.\ H - log.\ 0.38 = 1.86\ log.\ V - 1.25\ log.\ d.$$

We have here an equation of the form $A = B - C$, grouped as follows,

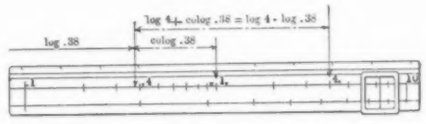


FIG. 3. SLIDE RULE ILLUSTRATION OF USE OF COLOR

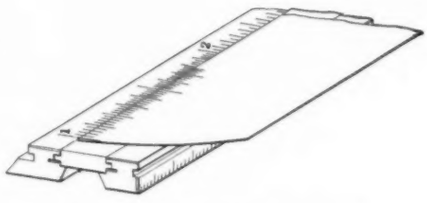


FIG. 4. METHOD OF TAKING OFF DIMENSIONS FROM A SLIDE RULE

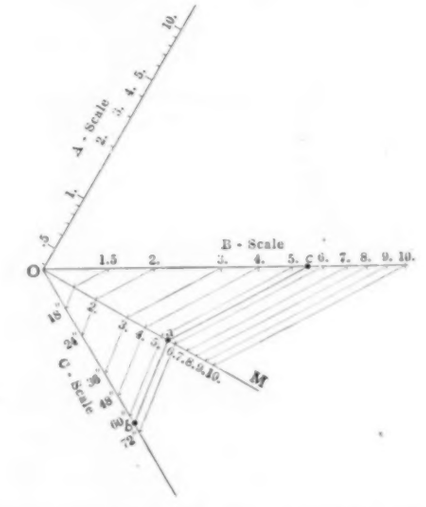


FIG. 5. METHOD OF GRADUATING THE AXES

$$(2') \qquad \overbrace{log.\ H - log.\ 0.38}^{A} = \overbrace{1.86\ log.\ V.}^{B} - \overbrace{1.25.\ log\ d}^{C},$$

each group involving but one variable.

Professor Peddle shows, page 341, how three lines, two forming an angle of 120 degrees and a third, their bisector, may be used to express the addition of two quantities as in Fig. 1. With the three axes graduated to the same scale, perpendiculars at values A and C on the outside lines will intersect on a perpendicular through B, a point on the bisector scale equal to the sum of A and B. This construction furnishes then a graphic solution for the

equation $B = A - C$. Transposing, we have $A = B - C$, the form of equation (2'). The hexagonal chart, therefore, can be used for equation (2) by arranging the scales as shown in Fig. 2. The completed chart is shown in Fig. 6.

The actual work of laying out the chart was as follows: The upper scale of an ordinary 10-inch slide rule was taken as a scale basis. The first term, *log.* H — *log.* 0.38, may be written *log.* H + *colog.* 0.38.

On the slide rule the distance from the left to 0.38 on the left scale is the logarithm of 0.38. The distance from 0.38 to the central index, 1, is equal to *log.* 1 — *log.* 0.38, or, since *log.* 1 = 0, to simply *log.* 0.38. If for any value of H, say 4, we measure from the point 0.38 of the left scale to 4 on the right scale, we have the distance corresponding to *log.* H — *log.* 0.38. If, therefore, the regular slide-rule graduations be transferred to the A-axis with the point 0.38 at O, Fig. 2, we have a scale of the first or A-term of equation (2).

To do this a piece of paper was inserted between the upper scales of the slide and frame, as shown in Fig. 4, and turned sharply over with the thumb nail. The graduations of the upper scale were carried over onto the paper with a sharp drawing pen and the scale reproduced with close accuracy and very quickly. This method saves much time over picking off the graduations with dividers, and eliminates any cumulative errors. The paper was then removed, cut along the crease, and 0.38 on the scale having been set on O in Fig. 5, the scale for the A-axis was laid off.

To obtain the graduations for the B and C terms, a line OM was drawn substantially bisecting the angle between the B and C axes. The paper scale, having done duty for the A-scale, was transferred to OM, this time being set with the index, 1, on O. These OM graduations were made lightly in pencil. An arbitrary distance Oa, say 4 inches, was laid off on OM and a distance Ob, one and one-fourth times Oa, in this case 5 inches, was laid off on the C-axis; ab was drawn and the scale projected over onto the C-axis, each point being carried over parallel to ab. The scale on C was then 1.25 times that of OM. If the OM scale was laid on the new one every point on the new scale would be the 1.25th power of the one opposite it. In a similar manner the distance $Oc = 1.86$, Oa was laid off on the B-axis and the graduations on the scale OM projected over parallel to ac, giving a scale of *log.* V 1.86. The axes B and C having been thus graduated the temporary scale OM was rubbed out.

Now, H and V may come to any odd value, but the values of d occur only in certain commercial sizes. Labor may be saved by picking out these only on the OM scale and carrying them over to the C-scale, marking their value either in feet or their equivalent in inches. In this case inches were used. The C-scale appears as in Fig. 6. In reality it is a regular logarithmic scale, the same as the others, but with the intermediate unused values left off.

As zero on a logarithmic scale corresponds to unity of the numbers considered, values of d less than 1 foot in diameter appear on the extension OC', and of V less than 1 foot per second appear to the left of O on OB'.

In this case as there were comparatively few graduations on the C-axis perpendiculars were extended across the chart as shown to facilitate reading. In reading the result a transparent index may be used as described by Professor Peddle, or if a square and 60-degree triangle are handy, these will be found quicker and less liable to error. As an example in reading the chart take the following: To find the mean velocity in an 18-inch pipe under a head of 4 feet per 1000. Project 4 on the A-scale perpendicularly over to the 18-inch line. From the intersection so found drop vertically to the desired value on the V-scale, 4.6 feet. Given any two of the three quantities H, V or d, the third can, of course, be found.

The above construction required but a few hours' work and when finished gave solutions well within the limits of accuracy of the data and the formula.

New Haven, Conn. JOSEPH W. ROE.

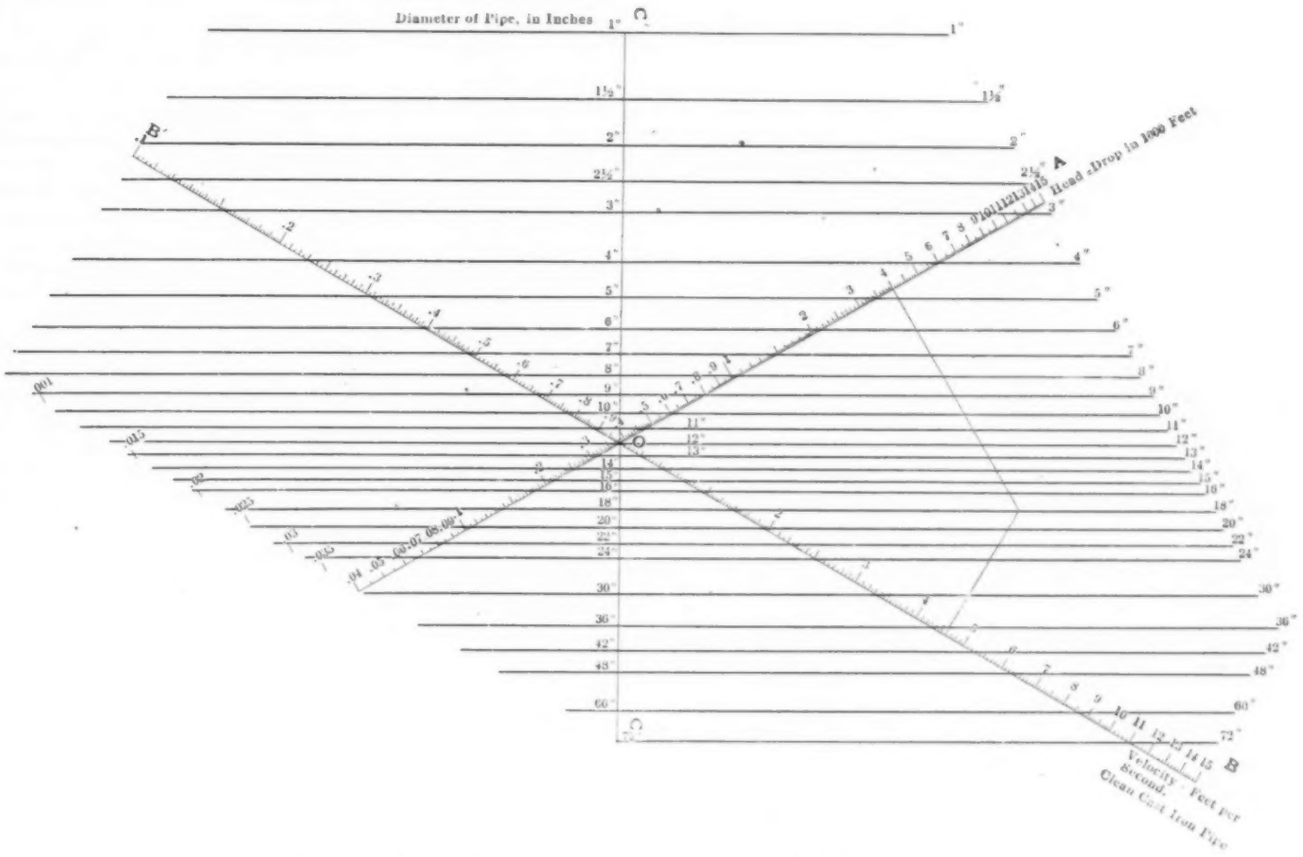


FIG. 6. CHART SHOWING RELATIONS BETWEEN HEAD, PIPE DIAMETER AND VELOCITY FOR CLEAN CAST-IRON PIPE

AMERICAN MACHINIST

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Nov. 19	18,750
Nov. 26	18,750

This paper reaches 33,750 *separate readers each month and* 18,750 *each week.*

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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The Value of Theoretical Analysis

In other columns we print a noteworthy article by Professor Hood, describing the methods that he pursued in balancing a rock crusher. The problem was one of machine construction, or rather machine reconstruction. The defects to be corrected, the method used, and the results obtained present several features that are worthy of consideration. First, the analysis and solution of the problem were accomplished entirely by theoretical means, a direct application of the principles of pure mechanics. Second, after the theoretical results had been reduced to practice, it was found that the desired end in the operation of the machine had been attained; thus theory and practice were in accord. Third, a graphical statement and solution of the problem were used, means undoubtedly easier to employ than a purely analytical treatment. Fourth, the constructional changes of the crusher were so simple, that we are surprised that no one had at least tried them from an experimental standpoint. The theoretical investigation pointed to the simplest kind of a change in the crusher, and but shows again how easily desired results can be obtained, provided they are considered properly from the standpoint of cause and effect.

Professor Hood's method of solving this balancing problem consisted in stating the problem graphically, by laying out the machine elements from the crusher; then by graphical differentiation and integration in plotting the acceleration curve for the unbalanced parts. This curve proved to be similar in characteristics to a sine curve, or the acceleration curve of a revolving unbalanced weight. After this fact had been established, it was a very easy matter to determine the size and location of counterweights to be fastened to the flywheel, which would balance properly the moving parts of the crusher, consisting of the jaw, pitman, toggle-joint and eccentric. When the weights thus determined were applied to the crusher, the vibration was reduced from 0.48 to 0.03 inch, the latter dimension a negligible quantity. Thus, a purely theoretical investigation led to the desired practical results, and has proved once more that true theory and consistent practice lead to the same end. Practice and theory are not opposed nor antagonistic, but rather when used properly are in perfect accord.

These columns have frequently expressed our approval of graphical analyses and graphical charts for determining and recording engineering data. Many times a graphical analysis is far simpler than a purely analytical one. In this case, as Professor Hood points out, it would have been difficult to obtain a mathematical expression for the motions and relationships of the crusher parts without introducing certain assumptions that would lead to incorrect results. The graphical method was by far the easier of the two. When we consider the simplicity of the structural change in the crusher in order to do away with the vibration, the adding of counterweights to the flywheels, we are surprised that someone has not tried this before, or at least has not developed it into a recognized feature of rock-crusher design.

An explanation may lie in the fact that it would not readily occur to anyone that a revolving counterweight could properly balance the vibrating jaw and its attached parts. However, now that the way has been shown, we shall expect to see the rock crushers designed in the future counterbalanced to eliminate vibration.

Leading a Horse to Water

Some two or three years ago the legislature of the State of Massachusetts passed an act requiring foundry owners to install suitable lavatory facilities for the use of their employees. A great point was made in the hearing before the legislative committee of the desires of the foundry operatives themselves in regard to such facilities.

A short time ago we visited a large manufacturing plant in eastern Massachusetts. As we approached the foundry the general manager said: "I want to show you our lavatory building that the State compelled us to build." He showed us a plain, yet pleasing, one-story brick structure, with an interior finished in white, well lighted and connected by a passageway with the foundry proper. The equipment consisted of a number of wash sinks of white porcelain-enameled iron, and a supply of metal lockers. The building was provided with heating appliances for cold weather. We expressed our interest in the installation and were surprised to be told that so far as the manager knew the building had never been used for the purpose intended; continuing he said: "I don't believe that it ever will be, for the boys have passed around the word, 'We have made 'em put it in, but don't use it.'"

Such incidents should not be overlooked by our legislative bodies when bills are being discussed that, if passed, will demand a positive action from one party, and require a voluntary action from the other party, in order that the intent of the bill shall be carried out. In the case that we have cited an investment of several thousand dollars had been made that was doing no good to anyone; in fact from one standpoint it might be considered a detriment, for the space occupied by the building could have been devoted to manufacturing purposes.

The question of coöperation on the part of employees is a real one in much industrial betterment of legislation. This point was recently brought out in an ar-

ticle in London *Engineering* discussing the new regulations for the operation of brass foundries throughout the United Kingdom. The regulations are beneficent in themselves, and because of the system of factory inspection the employers will live up to them; but will the employees do their part? Such was the substance of a question put in the article that we have referred to.

Taking it all in all, it is a pretty good plan to remember the old adage, "You can lead a horse to water, etc."

The Apprentice Schools in Cincinnati

The education of apprentices is being taken up in Cincinnati, Ohio, with great care and thoroughness, several of the shops having a regular school for this purpose. The Cincinnati Milling Machine Company, for example, organized its school in May, 1907, with 40 apprentices, one half meeting Tuesday, and the other Thursday evening. Later this was changed into day sessions from 10 a.m. to noon, the boys being paid for their time.

As anyone who has tried to teach boys of this age knows, the regular methods are of little use, the boys have not the study habit of the school; they cannot work well in classes, as no two are interested in the same thing, and many outside influences are at work. They were fortunate in securing the services of J. H. Renshaw, both on account of his personality which gets him closer to the boys than most teachers can get and his methods, which are so original as to attract attention and hold the boys' interest when presented by a man of his personality and enthusiasm.

In the first place the school has become a clearing house for shop troubles and the boy is free to tell his tale of woe to the instructor, no matter what its nature. In the second place Mr. Renshaw presents the questions so as to arouse interest, without which there will be no effort at study of any kind.

This school has made it clear that the average, real live boy cannot be interested in any prearranged course of study and that the personal contact with a tutor who can follow his mental perambulations, who can answer his questions and lead him to ask others, is absolutely necessary for the best results.

Mr. Renshaw has designed a series of lesson sheets or "jigs," as he calls them, which contains problems that the boy comes in contact with in the shop and that consequently interest him, to be worked out by the boy himself. These jig sheets include problems in angles, in setting dividing heads, in determining the variable motion of a crank-shaper ram; in fact, anything that is in the line of shop work, is practical and will interest the boy.

In this way the right tutor can drill a boy for a month calculating the angles of tapers and getting him thoroughly grounded in decimals, while the same boy will balk at a dozen ordinary examples that are given, just to see if he knows how to handle decimals. These jig sheets, and the methods in general are to be commended, especially when they can be handled by a man of Mr. Renshaw's personality, but without this even these become a prearranged course of study like the rest. Nor can this be avoided unless we can find some way of endowing the jigs with the personal magnetism of the successful teacher.

The officials of the company are deeply interested in the school and its workings, believing that it pays to have the most intelligent mechanics, that the education the boys are receiving is making them better fitted to meet any emergency, that it has developed a better understanding among all concerned and that the advantages far outweigh the expenditure involved. All admit, however, that more depends on the personality of the instructor and his faculty for drawing out the boys and explaining away difficulties than on any printed set of lessons that can be obtained.

Annual Meeting of the A. S. M. E.

The 29th annual meeting of the American Society of Mechanical Engineers will be held in the Engineering Societies building, 29 West Thirty-ninth street, New York, from December 1 to 4. The opening session will be at 8:45 p.m., Tuesday, December 1, at which Pres. M. L. Holman will present his address on "The Conservation Idea as Applied to the American Society of Mechanical Engineers."

The professional session of December 2 will begin at 9:30 a.m., and after the annual business meeting Morris Llewellyn Cooke will present "The Engineer and the People," and Major George O. Squier a paper on "Aëronautics." At 2 p.m. there will be four papers having to do with steam and power plants. These are: "A Method of Obtaining Ratios of Specific Heat of Vapors," by A. R. Dodge; "The Total Heat of Saturated Steam," by Dr. Harvey M. Davis; "Fuel Economy Test," by C. R. Weymouth; and "An Automatic System for Firing Fuel Oil," by the same author. At 8:15 p.m., Lieut. Frank P. Lahm, of the Signal Corps, U. S. A., will deliver an illustrated lecture on "Aëronautics."

The morning session of December 3, beginning at 9:30 a.m., will include "Efficiency Tests of Milling Machines and Milling Cutters," by L. A. DeLeeuw; "Metal Cutting Tools Without Clearance," by James Hartness; "Interchangeable Involute Gear Tooth System," by Ralph E. Flanders; "Durability of Gears in Electric Railway Service," by Norman Litchfield, and "Industrial Photography," by S. Ashton Hand. At 2 p.m. there will be papers as follows: "Articulated Compound Locomotives," by C. J. Mellin; "Liquid Tachometers," by Amasa Trobridge; "Training Workmen," by H. L. Gantt; "An Averaging Instrument for Polar Diagrams," by Prof. W. F. Durand; and "Salt Manufacture," by George V. Wilcox.

There will be a simultaneous session of the Gas Power Section, which will include a business meeting, "Reminiscences of a Gas Engine Designer," by L. H. Nash, and "Possibilities of the "Gasolene Turbine," by Prof. F. C. Wagner. The usual reception will be held at 9 p.m. on this date.

The closing session is at 9:30 a.m. on December 4, and includes "Physical Properties of Carbonic Acid and the Conditions of its Economic Storage for Transportation," by Prof. R. T. Stewart; "The Slipping Point of Rolled Boiler Tube Joints," by O. P. Hood and Prof. G. L. Christensen; and "Tests on Friction Clutches for Power Transmission," by Prof. Richard G. Duke.

Personal*

J. R. Gordon has recently accepted the position of manager of power-apparatus sales for the Western Electric Company for its Southern territory, and will make his headquarters in Atlanta, Ga. Mr. Gordon is a well known figure in the electrical field, and has for many years been a member of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers.

F. W. A. Joly, of Wittenburg, Halle, Germany, president of the Association of German Manufacturers of Fire Brick, arrived from Europe last week, and he expects to spend several weeks in this country studying American conditions of the firebrick industry. Mr. Joly is in a position to offer American manufacturers suggestions growing out of the experience of German makers, and will make his headquarters at the Hotel Astor, New York City, during his stay in this country.

John Kraus, city smoke inspector, of Cleveland, Ohio, gave a very interesting talk at the regular monthly meeting of the Metal Trades Superintendents' and Foremen's Club, which was held at the Hollenden hotel assembly room, on Saturday evening, November 14, 1908. After going very thoroughly through the various causes, effects and cures of the smoke evil, he illustrated by a steropticon various views of smoke stacks taken before and after adopting various appliances for the purpose of abating the smoke.

*Items for this column are solicited.

New Tools and Machine Shop Appliances

Showing New Ideas in Machine Shop Equipment That Make It Possible To Do Better Work at a Reduced Cost

THE LATEST INFORMATION

A Five-spindle Automatic Screw Machine

This is another lathe of the multiple-spindle class with five spindles, a four-space tool holder, threading bar and cross slides front and back. The headstock is cast solid with the bed and this has a three-point bearing on the base, which carries an oil pan of liberal size.

In Fig. 1, *A* is the stock feed operated by cam *J*, the details being shown more clearly in Fig. 2. *B* is the locking bolt, *C* the front cross slide with adjusting and stop screws and the stock stop. The tool slide has four flat faces and the main driving shaft runs through the center so that pulley *H* drives all the stock spindles. Back of this main shaft is the threading shaft *I*, which works in rather a novel way.

The stock is run at the normal speed at all times, but the tap or die is made to cut its thread by being revolved at a slower speed, but in the same direction as the stock. No reversal is necessary to back it off as the threading shaft is simply speeded up, when the die or tap runs off its thread. In this way the threads are cut at one-third the usual cutting speed and no stopping or reversing is necessary. Provision is made for a second threading spindle above the other, when desired.

The stock feed is adjusted by the set screw at *A*, which introduces lost motion between the feeding lever and the cam roll, but does away with all adjustment of the feeding cam. As the cutting tools are in operation during the feed no time is lost on that account.

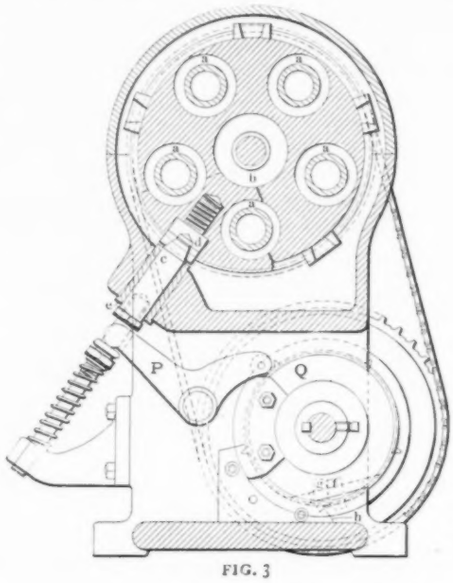


FIG. 3

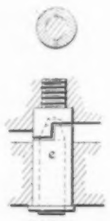


FIG. 4

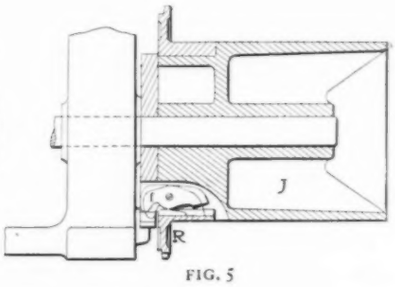


FIG. 5

DETAILS OF HEAD, LOCKING AND TURNING MECHANISM

The cam shaft is operated by pulley *O*, Fig. 2, through worm gearing, and this shaft is squared on each end to take a crank for hand adjustment, as at *E*. This shaft carries feed cam *J*, the indexing and locking cam *L*, cross-slide cam *M*, tool-feed slide cam *N*, while cam *F* controls the thread-cutting spindle and cam *G* the speed regulating dogs which give the slow-cutting and rapid-return feeds and other movements.

Going into more details of construction, Figs. 3, 4 and 5 show the locking bolt and head-revolving mechanism. The locking bolt *c* has a cone point, which fits the bushings *d* and *e*, one-half the cone being in each. This centers the head

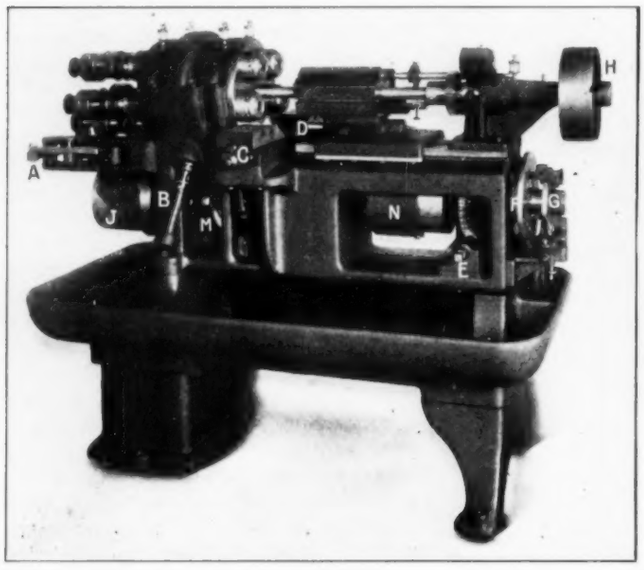


FIG. 1

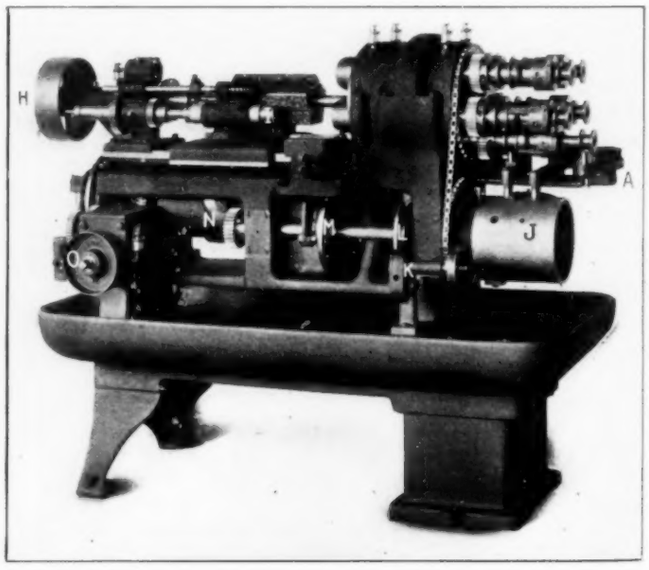


FIG. 2

FRONT AND REAR VIEWS OF FIVE-SPINDLE AUTOMATIC SCREW MACHINE

accurately without depending on the fit of the pin in the bushing. Fig. 4 shows how the bushings are divided. The locking bolt is operated by the bell crank *P* from the cam *Q*.

The head is turned by the chain and sprockets, the lower sprocket *R* being clutched at the proper time by the pawl *f* which is controlled by cam *h*. At other times the drum *J* turns inside the sprocket *R*.

The spindles run in bronze bearings, are adjustable for wear and have a double system of lubrication. The oil chambers *a* and *b* can be filled independently of the glass oilers shown, and the oil from these eventually finds its way to these chambers. Details of this are seen in Fig. 3.

The operation of the tool slides can be clearly seen. The tool differs from the usual box tools, all overhang being avoided, and adjustments are easily made, while one or more tools may be secured to the same face. The openness of design by which parts are readily accessible, is an interesting feature.

Change gears give ten feeds for cutting tools varying from 0.004 to 0.026 inch per revolution of the stock; but the quick return speeds are independent of the cutting feeds. The feed can be instantly cut out and locked so that the machine can be operated by hand without fear of accident. This machine has a capacity of 1 inch in diameter by 5 inches long and is made by the Peerless Automatic Machine Company, Cleveland, Ohio.

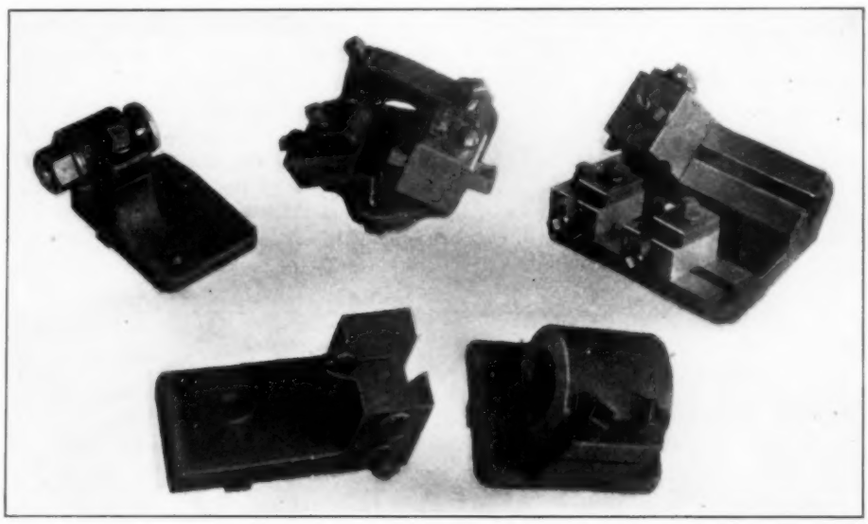


FIG. 6. BOX TOOLS AND HOLDERS OF THE PEERLESS AUTOMATIC

A Rolling Mill for Coining Work

Although the rolling mill illustrated is very similar to the usual design in general appearance, it contains a number of features which are new. The rolls are 10 inches in diameter and have a capacity of rolling strips 9 inches in width and up to ½ inch in thickness. The weight of the upper roll is supported by four heavy springs at a tension considerably in excess of the weight of the roll, this being regulated by the nuts shown at the top of the housings. This keeps the roll tight against the upper bearing surface, so as to eliminate the film of oil which is so desirable from a lubricating point of view, but which affects the extreme accuracy necessary in rolling strips for coinage.

The lower roll is stationary, and the adjustment of the upper is secured by long wedges, one of which can be seen projecting between the two housings. These wedges are controlled by a right and left screw connected with a train of gears to the dial crank, shown in Fig. 2. Should the rolls wear more on one side than the

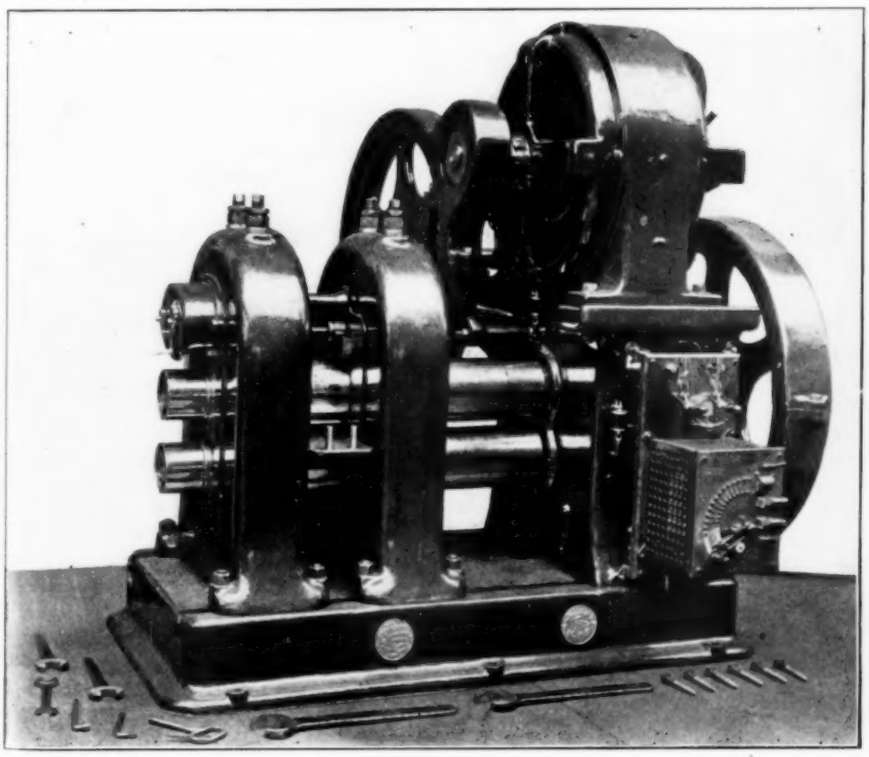


FIG. 1. ROLLS FOR MAKING COINING STRIPS

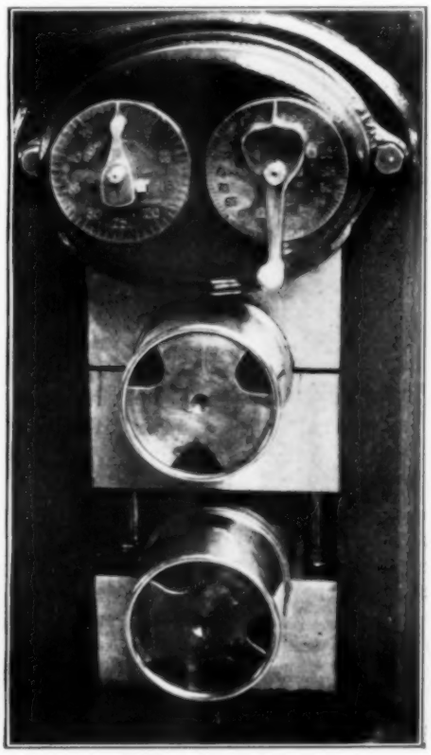


FIG. 2. DETAILS OF MEASURING DIAL

other, these wedges can be adjusted to compensate for this, so as to maintain perfect rolling of the strips.

The dials shown in Fig. 2 indicate the distance between the upper and lower rolls so as to show the thickness of the rolled strip. The dial at the right reads in ten-thousandths, while the one at the left reads in hundredths of an inch, and by moving the former one complete revolution, the left-hand indicator will be moved one notch, or 0.01 inch.

The extreme length of the machine is 8 feet 1 inch, the width 6 feet 8 inches, the hight 7 feet 9 inches, and the total weight, including the motor, is 25,000 pounds. All gears are guarded, as well as the end of the rolls. The motor is a 50-horse-power General Electric, wound for 220 volts, and geared at a ratio of 19.2, this giving 44 revolutions per minute to the rolls. This was designed by Oberlin Smith and built by the Ferracute Machine Company, Bridgeton, New Jersey.

Polishing Frame

This polishing frame has been designed for those who prefer an arbor running on cone points in maple blocks. The frame is curved toward the workman so that he

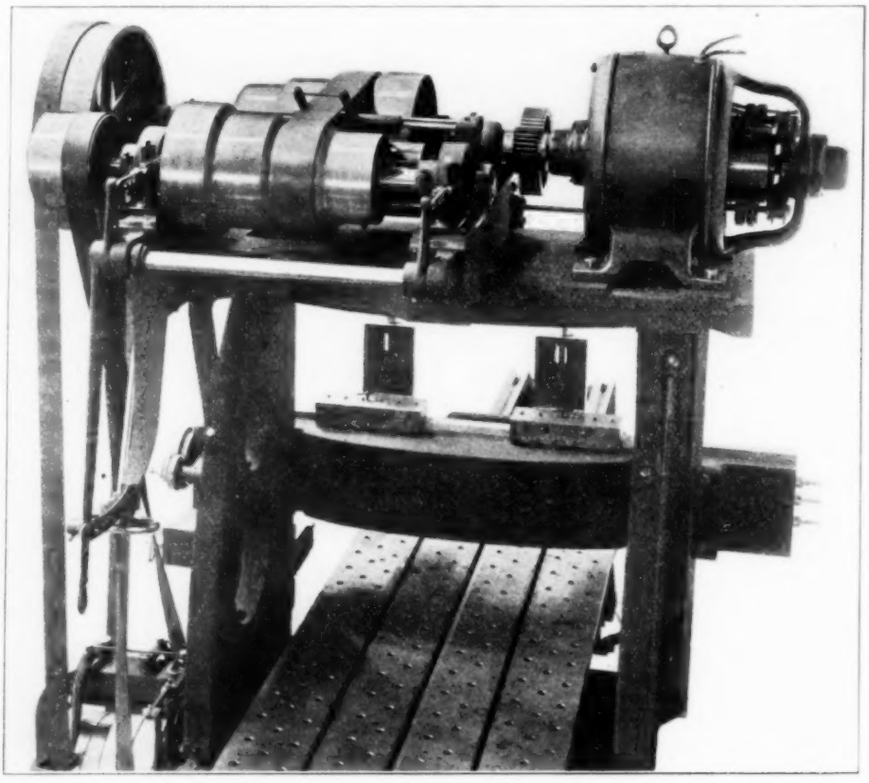
POLISHING FRAME

may get at a larger portion of the wheel than is possible when the uprights are straight, as usually made. This is an advantage in polishing tubes, cylinders, hollow ware, or irregular shapes. The wooden blocks fit in holes accurately bored and alined, and the adjustment of these blocks is obtained by the set screws shown, which do not, however, bear directly on the blocks themselves. Each screw has a drop-forged handle attached, so that they cannot be mislaid.

The base offers little obstruction on the floor in spite of its generous dimensions, and the weight and strength of the whole frame have been designed to resist vibration. The belts may be led off from overhead or rear countershafts as desired. The center of the spindle is 32 inches from the floor, the arbor is 12 inches long and the weight of the frame ready to ship is about 250 pounds. It is made by the New Britain Machine Company, New Britain, Conn.

A Speed Variator

The illustration shows a new speed variator which has been subjected to rigid and varied tests in the shop of the makers for over two and a half years. This device is for use in shops where the planer work is of such nature that different cutting speeds are desirable. It permits four different cutting speeds with one constant return speed.



A SPEED VARIATOR

It consists primarily of two inversely placed cones, one mounted on the constant-speed shaft on the end of which is the return pulley, the other mounted on the variable-speed shaft on the end of which is the cutting pulley. The constant-speed shaft may be driven either by belt directly from the line shaft, through a pair of tight and loose pulleys, or, as shown by the accompanying illustration, it may be geared to the motor shaft, thus making an entirely self-contained motor-driven equipment. The variable-speed shaft is driven from the constant-speed shaft through an endless belt.

The speed is changed by merely turning the hand wheel, which is conveniently located at the side of the housings, and which shifts the belt from step to step of the cones. The variable-speed shaft is moved to and from the constant-speed shaft by means of the long tightening lever which enables the operator to keep the belt at all times under the proper driving tension.

This lever also makes it possible to shift the belt while it is slack. To further facilitate the shifting, the shoulders of the cone steps are beveled off as shown, and the shifting mechanism is furthermore so arranged that one end of the belt is shifted onto the smaller step of one cone before the other end of the belt is shifted onto the larger step of the other cone. In consequence there is practically no wear on the belt due to shifting.

The hand wheel operates the duplex belt shifter by means of a cylindrical cam, mounted between the cones. The stationary pedestal bearings for the constant-speed shaft are fitted with phosphor-bronze bushes lubricated by ring oilers. The sliding pedestals for the variable-speed shaft are turned to form a socket for large ball-shaped cast-iron casings which are also fitted with ring-oiling phosphor-bronze bushes. This forms a universal, swiveling bearing, and insures perfect alinement of the shaft bearings under all conditions.

The speed can be changed without stop-

ping the motor. This saves considerable time, because it eliminates the necessity of waiting for the armature and pulleys to come to rest. The momentum of the two cones, supplementing that of the heavy flywheel pulley, reduces the strain on the motor at the moment of reversal. The device is simple and absolutely devoid of complicated or delicate parts that could get out of adjustment or cause trouble and annoyance. The elimination of rapidly running gears insures an almost noiseless drive. This speed variator is built by the G. A. Gray Company, manufacturers of metal planers, Cincinnati, Ohio.

Quick Change Drill Chuck

This is designed for work where a number of tools are used in succession, as it enables them to be changed rapidly without stopping the machine. The outfit necessary is one chuck *A* and as many collets *B* as there are tools in the series of operations. A collet is fitted to each tool, either by pinning them together with a hardened pin, or in any other way that may be suggested. These collets are drop-forged and may be had 0.005 inch over size to allow for grinding after being fitted to the shank and hardened. The chucks are hardened and ground.

In operation as in *C*, the collar is held by a light pressure, which overcomes the tension of a spiral spring within and throws the key slot in the chuck open so that the collet can either be inserted or released, as the case may be. Releasing the collar allows the spring to close the key slot and the next collet is secured ready for work. *D* shows the drill held securely in place.

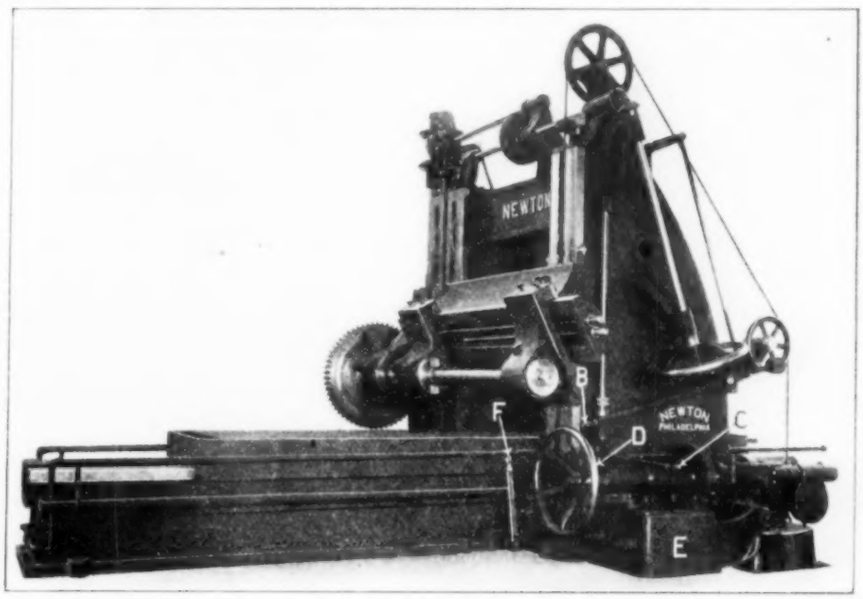
The cone-shaped end on the collet is of great assistance in entering it in the chuck; it also centers it and helps to hold it firmly for any work it may be called on to do. The drive is direct and powerful, and the collet is held so securely that it is well adapted for back-facing. They are made by the McCrosky Reamer Company, Inc., Meadville, Penn.

Large Horizontal Milling Machine

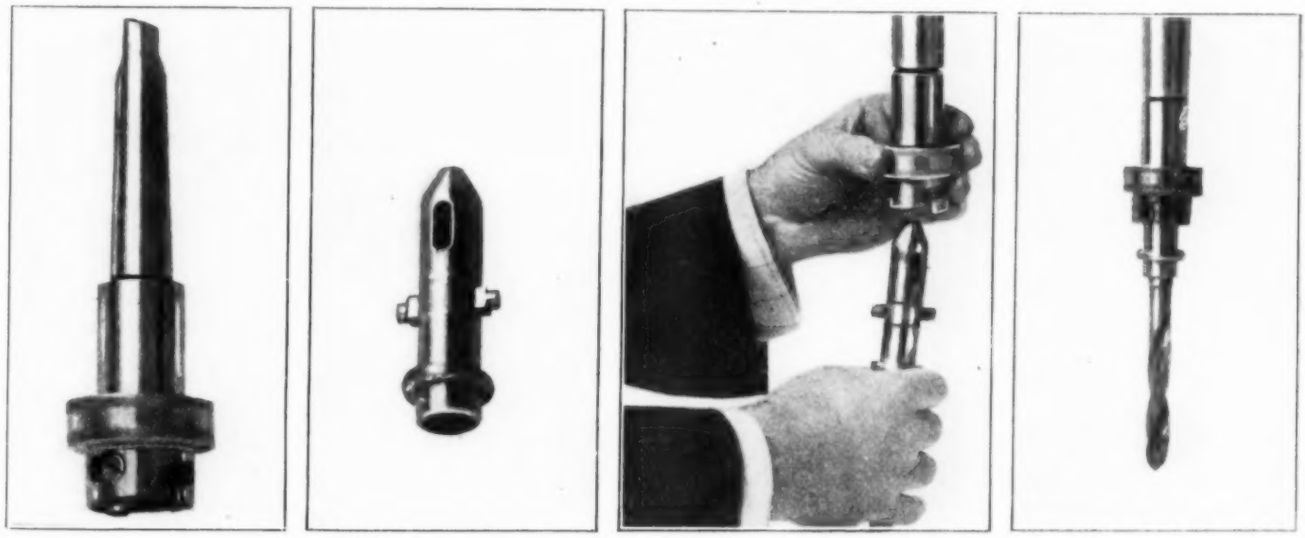
This is built for very heavy work, the spindle being 8¼ inches in diameter, with a cross adjustment on the rail of 12 inches for convenience in setting cutters. The drive is through the large triple-lead bronze worm wheel *A*, shown at the left with guards removed. The worm is hardened steel and the guard forms an oil case so that both run in an oil bath at all times.

The table is driven by a spiral gear and rack and has nine changes of geared feed through the speed box *E*. It can be moved by hand by the wheel *D* for adjustment to any point. Lever *C* controls a positive drive clutch which handles both the feed and fast traverse by power. By disengaging feed and throwing in lever *C*, the table is held securely in position for sinking cutters into the work.

The feed is driven by a horizontal shaft through clutched bevel gears to give either forward or reverse motion to the table, the direction being controlled by lever *F*. The cross rail is counterweighted and can be fed up or down by means of lever *B*. The elevating screws pull the rail down so that they are in tension when sinking cutters into the work. The screws have roller-thrust bearings at each end.



HORIZONTAL MILLING MACHINE



A B C D

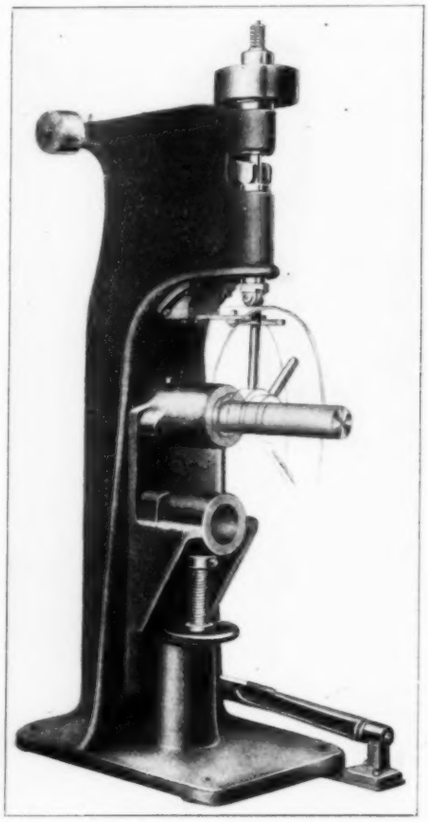
QUICK-CHANGE DRILL CHUCK

A gage screw with four nuts is provided for adjusting the rail to the same depth of cut on duplicate work. The table is 42 inches wide and will mill a piece 8 feet long. The uprights are 50 inches apart and greatest distance from top of table to center of spindle is the same. It weighs 96,000 pounds. It is made by the Newton Machine Tool Works, Philadelphia, Penn.

Pulley Riveting Machine

This is a large size of the rivet-spinning machine built by the Grant Manufacturing and Machine Company, Bridgeport, Conn., and has been designed to rivet the spokes in the rim of a steel pulley. This pulley has spokes of round steel 1⅛ inches in diameter, with the end turned down to ⅞ inch, which projects through the rim. After the required amount of metal had been determined by experiment, it was possible to rivet the heads down so closely that there would be almost no surplus metal to remove by grinding, the projection having been spun down to conform to the pulley's rim.

The two holes in the knee are to allow arbors to be placed in either location, so that pulleys from 12 to 60 inches in diameter can be riveted up on the same machine. After adjusting the knee into position, a pressure of the foot treadle brings the riveting head, or wheel, down against the metal, and the head is spun over quickly and without noise.



PULLEY RIVETING MACHINE

Tapping and Threading Machines

The illustrations show a new tapping and threading machine recently brought out by F. E. Wells & Son Company, Greenfield, Mass., which has a capacity up to ⅝ inch. The machine has internal back gearing, which is connected to the spindle by means of a friction clutch. This can be thrown out very quickly and another thrown in, which drives directly from the cone pulley and provides the reverse. This is accomplished by the lever shown in front of the machine, which is used to start, stop or reverse the spindle at will. On small work this can be done by simply pressing up or holding back on the tail block. This machine is also equipped with an automatic trip and reverse, which can be set at any desired point.

The tail block has hardened steel jaws for round or square work and false jaws can be easily made to hold odd-shaped pieces. The tail block can be set either side of the center when desired. The small lever at the back of the tail block is for starting the tap or die on the larger work, but is not needed on small work as the tail block can be pushed forward by hand.

A special chuck is provided for tapping, which centers the tap by the round shank, but drives by the squared end. The face of the tail block's jaws are planed off square so that flat pieces too

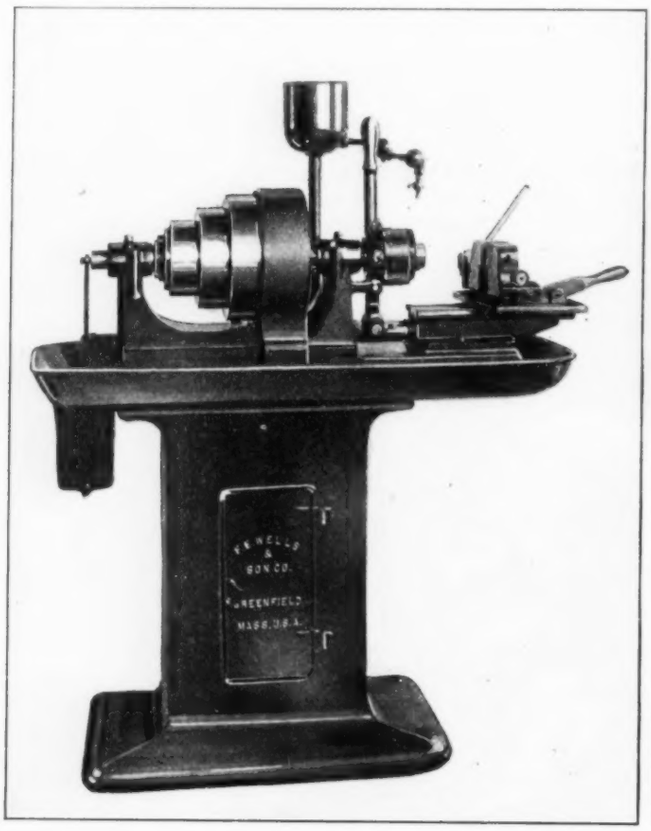


FIG. 1. TAPPING AND THREADING MACHINE

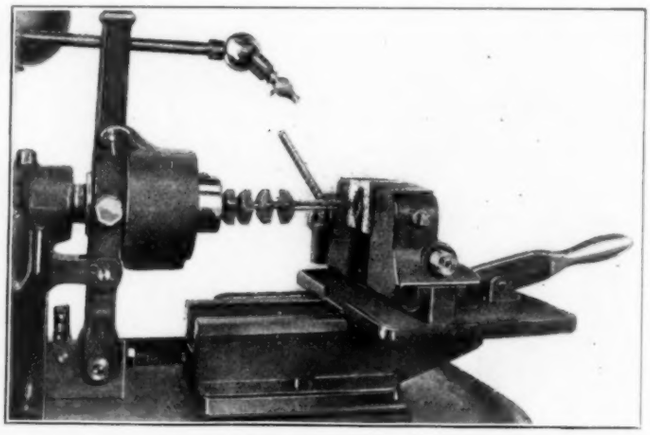


FIG. 2. USED AS A NUT TAPPER

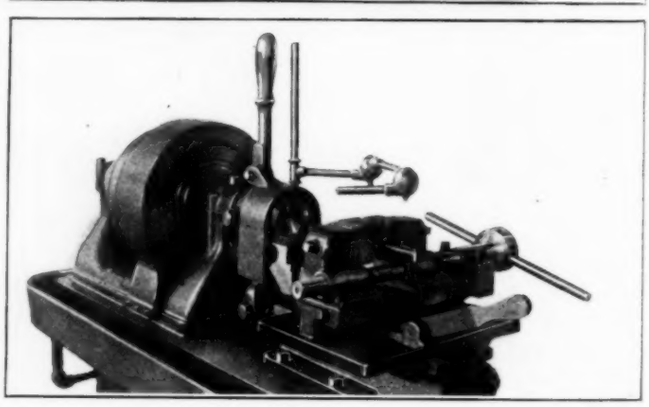


FIG. 3. CUTTING BOLTS

large to go between the jaws may be held against them. A plain plunger pump is provided for lubrication.

Reference Disks

The illustration shows a set of reference disks which is being placed on the market by J. T. Slocomb Company, Providence, R. I. These disks are made of good quality of steel, hardened very hard, and after being properly seasoned are finished to size. The sizes range from ¼ inch to 2 inches, rising by sixteenths. The ¼- and 5/16-inch sizes are made in one piece with the handle, while the other disks fit handles furnished with the set.

SET OF REFERENCE DISKS

The disks are centered on plugs secured to the bottom of the Morocco case. The plugs and disks are marked in common fractions and decimals. The disks are also obtainable singly.

Business Items

Northern Engineering Works, Detroit, has moved its Chicago office from 405 Monadnock block to 539 Monadnock block.

The English rights of the molding machines handled in this country by E. H. Mumford Company, Philadelphia, and in Europe by Ph. Bonvillian & E. Ronceray, Paris, have been sold to Greenwood & Batley, Albion Works, Leeds.

Robert W. Hunt & Co., consulting and inspecting engineers, 1121 The Rookery, Chicago, Ill., has been awarded by the Chicago & Northwestern Railroad Company the inspection of the structural materials entering into their new terminal station, of which the steel will amount to about 24,000 tons. The same firm has been given the inspection of the steel to be used in the new Blackstone hotel now being erected at the corner of Michigan avenue and Hubbard court.

Trade Catalogs

Buffalo Forge Company, Buffalo, N. Y. Catalog No. 197, describing Buffalo fan system of heating and ventilating. Illustrated, 142 pages, 6x9 inches, paper.

Crescent Tool Company, Jamestown, N. Y. Catalog of wrenches and pliers. Illustrated, 16 pages, 3½x6 inches, paper.

Westcott Chuck Company, Oneida, N. Y. Catalog D of lathe and drill chucks. Illustrated, 36 pages, 6x9 inches, cloth.

The Brown Hoisting Machinery Company, Cleveland, Ohio. Catalog E, describing grab buckets and tubs. Illustrated, 54 pages, 6x9 inches, paper.

General Electric Company, Schenectady, N. Y. Bulletin No. 4627, describing curve-drawing instruments for alternating and direct-current circuits. Illustrated, 20 pages, 8x10½ inches.

Western Electric Company, 463 West street, New York. Pamphlet entitled, "What the Western Electric Company is Doing to Increase the Central Station Load." Illustrated, 6½x9 inches.

The West Haven Manufacturing Company, New Haven, Conn. Catalog of band saws, hack saws and frames, power-hack saw machines, plumbers' hollow mill saws. Illustrated, 32 pages, 6x9 inches, paper.

The W. W. Oliver Manufacturing Company, 1483 Niagara street, Buffalo, N. Y. Catalog No. D-16, describing rolling mills, speed lathes, polishing machinery, drop presses, drills, etc. Illustrated, 106 pages, 3½x6½ inches, paper.

The Colton Combination Tool Company, Easthampton, Mass. Catalog describing combination lathe tool holder. Illustrated, 12 pages, 3½x6 inches. Circular illustrating and describing Colton steel cutter for high speed steel.

Crocker-Wheeler Company, Ampere, N. J. Bulletin No. 95, illustrating and describing belt type alternating generators. Bulletin No. 106, on d.c. switchboard panels. Bulletin No. 107, on direct-current lighting and power generators. Bulletin No. 108, on engine type alternating-current generators. Bulletin No. 109, on generating sets.

The Blake & Knowles Steam Pump Works, 115 Broadway, New York. Bulletin No. K-813 describing Knowles mine sinking pumps. Illustrated, 8 pages, 6x9 inches. Bulletin No K-814, on Knowles boiler feed and tank pumps. Illustrated, 20 pages, 6x9 inches. Bulletin No. B-815, Blake boiler feed and tank pumps. Illustrated, 20 pages, 6x9 inches. Bulletin No. B-817, Blake vertical high speed engine. Illustrated, 4 pages, 6x9 inches. Bulletin No. K-818, Knowles single horizontal piston pumps. Illustrated, 2 pages.

Business Opportunities

The Newark (N. J.) Tube and Metal Works is erecting a new plant.

The Acme Wire Company, New Haven, Conn., will erect a new factory.

The Crown Iron Bed Company, Atlanta, Ga., will locate in Cincinnati, Ohio.

The Shoe Hardware Company, Waterbury, Conn., will erect a new factory.

The Hammond Iron Works, Warren, Penn., will erect two additional buildings.

The Allyne Brass Foundry Company, Detroit, Mich., will have an addition erected.

The Royal Brass Manufacturing Company, Cleveland, Ohio, will erect a new plant.

The Western Maryland Railroad Company will enlarge its shops at Hagerstown, Md.

The Indiana Rolling Mill Company, Newcastle, Ind., will erect three additional buildings.

The Springfield (Ill.) Wire Screen Company, whose plant recently burned, will rebuild.

The plant of the American Can Company at San Francisco, Cal., was destroyed by fire.

The Bonney Vise and Tool Company, Philadelphia, Penn., will remove its plant to Allentown.

The plant of the Ellisville (Miss.) Lumber Company was burned, causing a loss of $100,000.

The F. W. Black Lumber Company, Nashville, Tenn., will rebuild plant recently burned.

The foundry of the Gibbes Machinery Company, Columbia, S. C., was partially destroyed by fire.

The Columbus (Miss.) Machine and Foundry Company will rebuild plant recently destroyed by fire.

The Bass Foundry and Machine Company Ft. Wayne, Ind., will build an addition to its foundry.

The John Rauschenberger Cordage Company, Milwaukee, Wis., will erect a new rope and twine factory.

The plant of the Nashville (Tenn.) Saddlery Company was destroyed by fire. Loss, about $140,000.

The Shearwood (Ga.) Lumber Company will establish sawmill, planing mill and dry kiln at Brooklet, Ga.

The Northwestern Electric Equipment Company, St. Paul, Minn., will establish a factory in Minneapolis.

The Faeth Iron Company, Kansas City, Mo., has bought site on which a plant to cost $100,000 will be erected.

The Fox Paper Company, Lockland, Ohio, whose plant was recently burned, will rebuild on a larger scale.

The E. C. Long Manufacturing Company, Hannibal, Mo., will erect a four-story garage and machine shop.

The Petoskey (Mich.) Block and Manufacturing Company will rebuild burned plant at a cost of $100,000.

The Richardson & Boynton Stove Company, Dover, N. J., has had plans drawn for three additional buildings.

The Reading (Penn.) Iron Company is said to be preparing plans for a new pipe mill to replace present one.

Verda (La.) Lumber Company will rebuild saw and planing mills destroyed by fire at a loss of about $50,000.

The York Manufacturing Company, York, Penn., is building an addition to be used as a malleable iron foundry.

The plant of the Shawmut Motor Company, Stoneham, Mass., was destroyed by fire, causing a loss of about $115,000.

The Western Street Car and Foundry Company, Old Colony building, Chicago, Ill., has selected site for a foundry.

The Farmers' Warehouse and Gin Company, Pocahontas, Ark., has been incorporated. C. H. Carter, president. Will erect cotton gin.

The planing mill and machine shop of the Camden (N. J.) Shipbuilding and Repairing Company were burned. Loss, about $30,000.

It is reported that W. H. Rogers & Son, Adrian, Mich., propose to establish a plant for manufacturing wire fencing in Gainesville, Texas.

The Southwestern Interurban Railroad will construct repair shops and power station at Mangum, Okla. J. W. Solomon, Reed, Okla., president.

W. H. Wharton and E. L. Traylor, Memphis, Tenn., are erecting a foundry and machine shop for the manufacture of castings and special machinery.

The Webster Full-Expansion Rotary Engine Company, St. Joseph, Mo., recently incorporated, will erect plant. Geo. Lamont Webster is president.

It is reported that the Queen & Crescent Route will construct repair shops at Somerset, Ky. H. E. Warrington, Cincinnati, Ohio, chief engineer.

The Gibson Refrigerator Company, Greenville, Mich., has been organized to manufacture refrigerators. Capital, $100,000. Frank F. Gibson, president.

The Lozier Motor Company, Plattsburgh, N. Y., has completed plans for additions at plant. These include machine shop, blacksmith shop and testing building.

The Campbellsport (Wis.) Wooden Ware Company has been incorporated with $10,000 capital to manufacture boxes, crates, etc. Incorporators, E. E. Martin, M. A. T. Hoffman and William Knickel.

The Baker Manufacturing Company, New Haven, Conn., has been incorporated to manufacture spark plugs and other automobile parts. O. L. Hemming, G. F. Hemming and M. L. Baker, incorporators.

The Navy Department, Bureau of Supplies and Accounts, Washington, D. C., will open the following bids: December 8—Leather belting (schedule 638), 2 scotch boilers (schedule 619), surface grinding machine (schedule 628), water meters (schedule 633), automatic bevel gear planer (schedule 620), brass and copper tubing (schedule 637), tap bolts (schedule 634), micrometers, saws, machine screws, stocks and dies (schedule 636), locomotive, rails, spikes, switches, etc. (schedule 629). December 15—Oil-fuel furnace (schedule 631), 20-inch shaper (schedule 632). December 22—Leather belting, pipe fittings (schedule 627), screws, machinists' taps (schedule 625).

Want Advertisements

Rate 25 cents per line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Caliper list free. E. G. Smith Co., Columbia, Pa.

We buy or pay royalty for good patented machine or tool. Box 282, AMER. MACH.

Wanted—Orders for brass goods. Castings and finished product. Box 601, AMER. MACH.

Hand power bending tools, labor-saving, money-making. Estep & Dolan, Sandwich, Ill.

Braze cast iron with Universal Fluxine, $.50 per pound. Universal Fluxine Co., Urbana, Ohio.

Machinery built to order. Up-to-date plant. Write Brunswick Refrigerating Co., New Brunswick, N. J.

Light fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

Send for circulars and price list of radius gauges, metal tool box and ratchet tap, wrenches. F. G. Marbach, Medina, Ohio.

Machines designed; automatic, special. Practical working drawings. C. W. Pitman, 3519 Frankford Ave., Philadelphia, Pa.

Special machinery accurately built. Screw machine or turret lathe work solicited. Robert J. Emory & Co., Newark, N. J.

British patents law. Factory sites between Liverpool and Manchester with water, coal, electric power, railroad, tramcars. Hulton Park, Bolton, England.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

A large English firm of machine-tool importers having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMER. MACH.

Cost reducing machinery designed and built. Guaranteed per cent. on investment. Send sample or sketch of work and cost of manufacture. Remington M'f'g. Co., Fitchburg, Mass.

An established manufacturer owning a large foundry and machine shop with modern equipment and 15-ton electric crane, desires to get some young blood and a good line of heavy iron machinery, engin or tools to manufacture. Address, with particulars, as to line offered. Box 640, AMERICAN MACHINIST.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

COLORADO

Practical machinist and mechanical engineer desires position as master mechanic or superintendent. Western states preferred; holding similar position but wish change. Box 668, AMERICAN MACHINIST.

CONNECTICUT

High grade superintendent wants good position; up in recent methods in all departments and organization. Energetic, executive, a producer. Box 654, AMERICAN MACHINIST.

GEORGIA

Position as superintendent of machine work on engines and electrical machinery. Box 639, AMERICAN MACHINIST.

MASSACHUSETTS

Brass foundry foreman wishes position, jobbing, pump or valve foundry preferred. Dry sand, skin dry moulding, moulding machines, etc. All kinds of bronzes. Twenty-two years' experience, 9 years foreman. Hard worker; references. Box 645, AMER. MACH.

MICHIGAN

Young man, thorough, practical mechanic, experienced in superintending the manufacture of automobiles and high grade interchangeable machinery; of good executive ability. Also designer of tools and fixtures and expert on 2-cycle engine work. Open for engagement. Address Box 675, AMERICAN MACHINIST.

NEW JERSEY

Thirteen years an executive on tools and manufacturing, designing methods and tools. Reducing costs, practical and thorough, broad experience, modern. Best references. Box 622, AMERICAN MACHINIST.

Mechanical engineer wishes to make change about Jan. 1, 1909. Has held positions of chief draftsman, engineer and superintendent; twenty years' experience; no preference as to location. Box 686, AMER. MACH.

NEW YORK

High class inventor, model maker and draftsman. Box 670, AMERICAN MACHINIST.

A-1 toolmaker and designer; an all-round workman. Box 671, AMERICAN MACHINIST.

Blue print expert; black line, negative printer, paper sensitizer. H. R. Guile, Dolgeville, N. Y.

Draftsman, graduate M. E., 3 years' drafting experience, wants position. Box 684, AMERICAN MACHINIST.

Mechanical draftsman, also first class all-round machinist and good lathe hand, wishes position. Box 672, AMERICAN MACHINIST.

Draftsman, 22, three years' experience, structural steel general machinery, excellent references, desires position. Box 687, AM. M.

Mechanical draftsman, technical graduate in Sweden, five years' experience, working ability and skill. Box 678, AMERICAN MACH.

Draftsman, mechanical, experienced on automatic machinery; technical graduate; first class detailer; anywhere. Box 677, AM. MACH.

Mechanical draftsman desires change of position, seven years' experience, machine design, power plants, etc.; technical. Box 667, AMERICAN MACHINIST.

Draftsman, competent mechanical, technical graduate, 28, with five years' experience, wants position. Salary upon merits. "Capable," 22 East 4th St., New York City.

Expert wishes position to invent, design or improve automatic or special machinery. Present connection in New Jersey. Would like to locate in New York City. Box 673, AMERICAN MACHINIST.

Mechanical engineer, wide experience, maintenance, betterments, new construction, machine shops, iron and brass foundries, power plants, furnaces, drop forge; practical mechanic and executive, technical education. Box 685, AMERICAN MACHINIST.

Designer and mechanical engineer, 14 years' practical training on complex automatic machines, heavy machine tools, electrical machinery, hydraulics. Inventive ability to a high degree. Thoroughly modern and able to take charge. Address "Arthur," care AMERICAN MACHINIST.

OHIO

A patternmaker with 15 years' experience as foreman with some of the largest concerns in the Middle West wants to invest some money with services in a growing, reliable concern where ability and diligence will be appreciated. Am of middle age, of good character, have a family and wish to locate permanently. Box 665, AMERICAN MACHINIST.

PENNSYLVANIA

Expert designer on Corliss engines, pumping and blowing engines, power transmission, is open for engagement. Competent to take charge. Box 662, AMERICAN MACHINIST.

Mechanical and electrical engineer with five years' American experience on gas engines and producers, plans, etc., free for engagement. Box 682, AMERICAN MACHINIST.

Manager of machine works will change; twenty years' experience, covering design and building of plants, machines, purchasing and production. Box 683, AMERICAN MACHINIST.

Young man with domestic and foreign experience in shop work and selling, now employed in executive capacity, desires position as agent with reliable concern; salary and commission. "Experience," 31 So. 16th St., Philadelphia, Pa.

Help Wanted

Classification indicates present address of advertiser, nothing else.

ILLINOIS

A prominent Chicago machine tool merchant desires to engage the services of three first class salesmen of established ability who are well and favorably known to the Middle Western trade. Box 631, AMERICAN MACHINIST.

INDIANA

Wanted—Two inspectors, two grinders, six lathe men, two toolmakers, one foreman, four machinists, all for work on gasolene motors. Good wages. Box 666, AMERICAN MACHINIST.

KANSAS

Wanted—Blacksmith for foreman of college shop. Require an expert smith who has ability and patience to instruct students. Salary to start $900.00 for 11 months. Box 663, AMERICAN MACHINIST.

MASSACHUSETTS

Wanted—Competent accountant for factory employing between 200 and 300 hands. Manufacturing all kinds of light and medium weight mechanical devices; must be thoroughly competent to keep itemized labor and material costs, piece work, day work, etc., and must have experience with raw and finished material, ordering and general stockkeeping accounts where many thousands of parts are involved. Give detailed account of experience and salary expected. Box 676, AMERICAN MACHINIST.

MISSOURI

A large electrical manufacturing company requires a capable, experienced foreman for its indicating instrument department; previous experience indispensable. Apply, giving experience and salary expected. All communications confidential. Box 680, AMER. MACH.

NEW YORK

How would you like to increase your income? If you're a machinist and know other machinists or draftsmen, you can do it easily. We want you to act as our special representative in your shop for the American Machinists' Handbook. This is the best book by all measures that has ever been published by machine makers. When you sell one to a man you're doing him a favor and he'll tell you so after he's had the book awhile. They are outselling all other books. We've a very liberal proposition to offer you and suggest you write us today. Book Dep't., Hill Publishing Co., 505 Pearl Street, New York.

OHIO

Draftsman for machine tool work. Wide experience necessary, preferably turret lathes and tools for same. Give detailed particulars regarding experience and state age and education. Address Box 664, AMER. MACH.

PENNSYLVANIA

Rivetmaker. Wanted, a first-class mechanic who understands the running of double-stroke headers; permanent position with good pay. Apply Metallic Specialty Mfg. Co., 1616 N. 21st St., Philadelphia, Penn.

Chief draftsman wanted by prominent gas engine builders; must be good organizer, familiar with modern drafting room and shop practice; man with good gas engine experience preferred. Box 679, AMERICAN MACHINIST.

Electroplater, must understand basket work and the handling of small metal goods in bulk; one speaking German preferred; permanent position with good pay to one who can handle twelve men and show results. Metallic Specialty Mfg. Co., 1616 N. 21st St., Philadelphia, Penn.

WASHINGTON

Wanted—By prominent engineering house on the North Pacific Coast—a practical mechanical draftsman. One acquainted with power plant design preferred. Splendid opening for one who is in earnest. Address, giving full particulars as to qualifications, salary wanted, etc. Box 647, AMERICAN MACHINIST.

WISCONSIN

Wanted—A man to take charge of and grind cutters, such as reamers, milling cutters, etc., in tool room for large concern. Must be one who thoroughly understands the business. State experience, with whom, pay expected, etc. Address Box 669, AMERICAN MACHINIST.

For Sale

For Sale, absolutely new, a No. 2½ heading machine and a No. 2½ reheading machine, Waterbury-Farrel make, never used. Ohlen Company, Box 740, Columbus, Ohio.

Land for sale for building purposes for the erection of works, etc., in Manchester, England, and its immediate neighborhood, convenient for railway and canal traffic. Full information from the Hon. John E. Cross, Land Agent, High Legh, Knutsford, England.

Steel ball machinery for rolling hot steel and making balls ⅛ to ¾ in size, and other cylindrical forgings; also the wood patterns for making the machines; also three Putnam and one Dodge horse nail machines; for sale by H. T. Marshall Machine Co., 80 Ward St., Brockton, Mass.

For Sale—Tracings, patterns, jigs and templets for the following size gas and gasolene engines: 1½, 3 and 5 horsepower vertical and 3, 5, 8, 10, 12, 16 and 20 horsepower horizontal; also a number of finished and unfinished engines of the above sizes. All of the above sizes have been in successful operation for several years. This is a splendid opportunity for anyone wishing to build gas or gasolene engines. You can save thousands of dollars in experimental work by purchasing this complete outfit. Shop rights of valuable patents on these engines will be given to purchaser. Box 366, AMERICAN MACHINIST.

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Abrasive Materials

Abrasive Material Co., Phila., Pa.
American Emery Wheel Co., Providence, R. I.
Carborundum Co., Niagara Falls, N. Y.
Dickinson, Thos. L., New York.
Norton Co., Worcester, Mass.
Safety Emery Wheel Co., Springfield, O.
Vitrified Wheel Co., Westfield, Mass.

Air Lifts

Ingersoll-Rand Co., New York.

Alundum

See Grinding Wheels.

Arbor Presses

Barnes Co., W. F. & John, Rockford, Ill.
Marshall & Huschart Machinery Co., Chicago, Ill.
Niles-Bement-Pond Co., New York.
Wilmarth & Morman Co., Grand Rapids, Mich.

Arbors

Cleveland Twist Drill Co., Cleveland, O.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Union Mfg. Co., New Britain, Conn.
Union Twist Drill Co., Athol, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Barrels, Steel

Lyon Metallic Mfg. Co., Aurora, Ill.

Bars, Boring

Beaman & Smith Co., Prov., R. I.
Cleveland Twist Drill Co., Cleveland, O.
Elmes Engineering Works, Chas. F., Chicago, Ill.
Krieger Tool & Mfg. Co., Chicago, Ill.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Underwood Co., H .B., Philadelphia, Pa.

Bearings, Ball and Roller

Boston Gear Works, Norfolk Downs, Mass.
Grant-Hoover Ball Co., Merchantville, N. J.
Hess-Bright Mfg. Co., Philadelphia Pa.

Balls, Steel

Grant Hoover Ball Co., Merchantville, N. J.
Hyatt Roller Bearing Co., Harrison, N. J.

Belt Dressing

Cling-Surface Mfg. Co., Buffalo, N. Y.
Desmond-Stephan Mfg. Co., Urbana, Ohio.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Belt Fasteners

Bristol Co., Waterbury, Conn.

Belt Filler

Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Belt Lacing Machine

Birdsboro Steel Foundry & Mach. Co., Birdsboro, Pa.

Belt Shifter

The L. & D. Co., Boston, Mass.

Belting, Leather

Chicago Raw Hide Mfg. Co., Chicago, Ill.
Schieren Co., Chas. A., New York.
Shultz Belting Co., St. Louis, Mo.

Benches, Work

Manufacturing Equipment & Engineering Co., Boston, Mass.

Bending Machinery, Hydraulic

Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Phila., Pa.
Watson-Stillman Co., New York.

Bending Machines, Plate

Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.

Bending Machines, Power

Boynton & Plummer, Worcester, Mass.
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Bending Tools, Hand

Estep & Dolan, Sandwich, Ill.
Wallace Supply Co., Chicago, Ill.

Blocks, Chain

See Hoists, Hand.

Blocks, Die

Nicholson & Co., W. H., Wilkes-Barre, Pa.

Blowers

American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
General Electric Co., New York.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Roth Brothers & Co., Chicago, Ill.
Sturtevant Co., B. F., Hyde Park, Mass.

Bolt and Nut Machinery

Acme Mchry. Co., Cleveland, O.
Boynton & Plummer. Worcester, Mass.
Davis Machine Co., W. P., Rochester, N. Y.
Foote-Burt Co., Cleveland, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Landis Machine Co., Waynesboro, Pa.
Lang Co., G. R., Meadville, Pa.
Manville Mach. Co., E. J., Waterbury, Conn.
McCabe, J. J., New York.
Milton Mfg. Co., Milton, Pa.
Mummert, Wolf & Dixon Co., Hanover, Pa.
National-Acme Mfg. Co., Cleveland, O.
National Machinery Co., Tiffin, O.
Newton Machine Tool Wks., Inc., Phila., Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Engineering Works, Ellwood City, Pa.
Vandyck Churchill Co., New York.
Waterburry Farrel Fdry. & Mach. Co., Waterbury, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Bolts and Nuts

Electric Welding Products Co., Cleveland, Ohio.
Milton Mfg. Co., Milton, Pa.
National-Acme Mfg. Co., Cleveland, O.

Bone for Case Hardening

Rogers & Hubbard Co., Middletown, Conn.

Books, Technical

American School of Correspondence, Chicago, Ill.
Hill Publishing Co., New York.
Sames, Chas. M., Jersey City, N. J.
System Co., Chicago, Ill.

Boosters

Burke Electric Co., Erie, Pa.
G & C Electric Co., New York.
Crocker-Wheeler Co., Ampere, N. J.

Boosters—*Continued.*

General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Roth Bros. & Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Boring and Drilling Machines, Horizontal

Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Betts Mach. Co., Wilmington, Del.
Boynton & Plummer, Worcester, Mass.
Detrick & Harvey Mach. Co., Wilmington, Del.
Fitchburg Machine Works, Fitchburg, Mass.
Fosdick Mach. Tool Co., Cin., O.
Gisholt Mach. Co., Madison, Wis.
Hill, Clarke & Co., Inc., Boston, Mass.
Lucas Mach. Tool Co., Cleveland, O.
McCabe, J. J., New York.
Motch & Merryweather Machinery Co., Cleveland, O.
New Haven Mfg. Co., New Haven, Conn.
Newton Mach. Tool Works, Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Universal Boring Mach. Co., Hudson, Mass.
Vandyck Churchill Co., New York.
Whitcomb-Blaisdell Mach. Tool Co., Worcester, Mass.

Boring and Turning Mills, Vertical

American Tool Works Co., Cin., O.
Baker Bros., Toledo, O.
Baush Mach. Tool Co., Springfield, Mass.
Betts Mach. Co., Wilmington, Del.
Bullard Mach. Tool Co., Bridgeport, Conn.
Colburn Mach. Tool Co., Franklin, Pa.
Gisholt Mach. Co., Madison, Wis.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
McCabe, J. J., New York.
Mitts & Merrill, Saginaw, Mich.
Newton Machine Tool Wks., Inc., Phila., Pa.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Boring Tools

Armstrong Bros. Tool Co., Chicago, Ill.
Krieger Tool & Mfg. Co., Chicago, Ill.

Box Tools, Roughing

Bardons & Oliver, Cleveland, O.

Brazing

Industrial Oxygen Co., New York.
Sanford Mfg. Co., F. C., Bridgeport, Conn.

Broaching Machines

Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Lapointe Mach. Tool Co., Hudson, Mass.

Bulldozers

Bliss Co., E. W., Brooklyn, N. Y.
National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.

Cabinets, Tool

Armstrong Bros. Tool Co., Chicago, Ill.
Hammacher, Schlemmer & Co., New York.
Morse Twist Drill & Mach. Co., New Bedford, Mass.

Calipers

Brown & Sharpe Mfg. Co., Providence, R. I.
Schuchardt & Schutte, New York.
Slocomb Co., J. T., Providence, R. I.
Starrett Co., L. S., Athol, Mass.

Cams

Bilgram, Hugo, Phila., Pa.
Boston Gear Works, Norfolk Downs, Mass.

Carborundum

See Grinding Wheels.

Carborundum Paper and Cloth

Carborundum Co., Niagara Falls, N. Y.

Case-Hardening

American Gas Furnace Co., New York.
Rogers & Hubbard Co., Middletown, Conn.
Williams & Co., J. H., Brooklyn, N. Y.

Castings, Brass and Bronze

Clum & Atkinson, Rochester, N. Y.
Lumen Bearing Co., Buffalo, N. Y.

Castings, Die Molded

Berry & Parker, Erie, Pa.
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Castings, Iron

Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Cell Drier Machine Co., Taunton, Mass.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Taylor & Fenn Co., Hartford, Conn.

Castings, Steel

Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.

Cast Iron Brazing

Industrial Oxygen Co., New York.

Cement, Cast Steel

Obermayer & Co., S., Cincinnati, O.

Centering Machines

Hendey Mach. Co., Torrington, Conn.
McCabe, J. J., New York.
National Machine Co., Hartford, Conn.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Whiton Mach. Co., D. E., New London, Conn.

Centers, Planer

Cincinnati Planer Co., Cincinnati, O.
Fay & Scott, Dexter, Me.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Pratt & Whitney Co., Hartford, Conn.
Woodward & Powell Planer Co., Worcester, Mass.

Chains, Driving

Boston Gear Works, Norfolk Downs, Mass.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Link-Belt Co., Philadelphia, Pa.
Morse Chain Co., Ithaca, N. Y.
Whitney Mfg. Co., Hartford, Conn.

Chucking Machines

American Tool Wks. Co., Cin., O.
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Automatic Machine Co., Cleveland, O.
Gisholt Machine Co., Madison, Wis.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
McCabe, J. J., New York.
Reed Co., F. E., Worcester, Mass.
Warner & Swasey Co., Cleveland, Ohio.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.
Windsor Mach. Co., Windsor, Vt.

Chucks, Drill

Almond Mfg. Co., T. R., Ashburnham, Mass.
Brown & Co., R. H., New Haven, Conn.
Celfor Tool Co., Chicago, Ill.
Cleveland Twist Drill Co., Cleveland, O.